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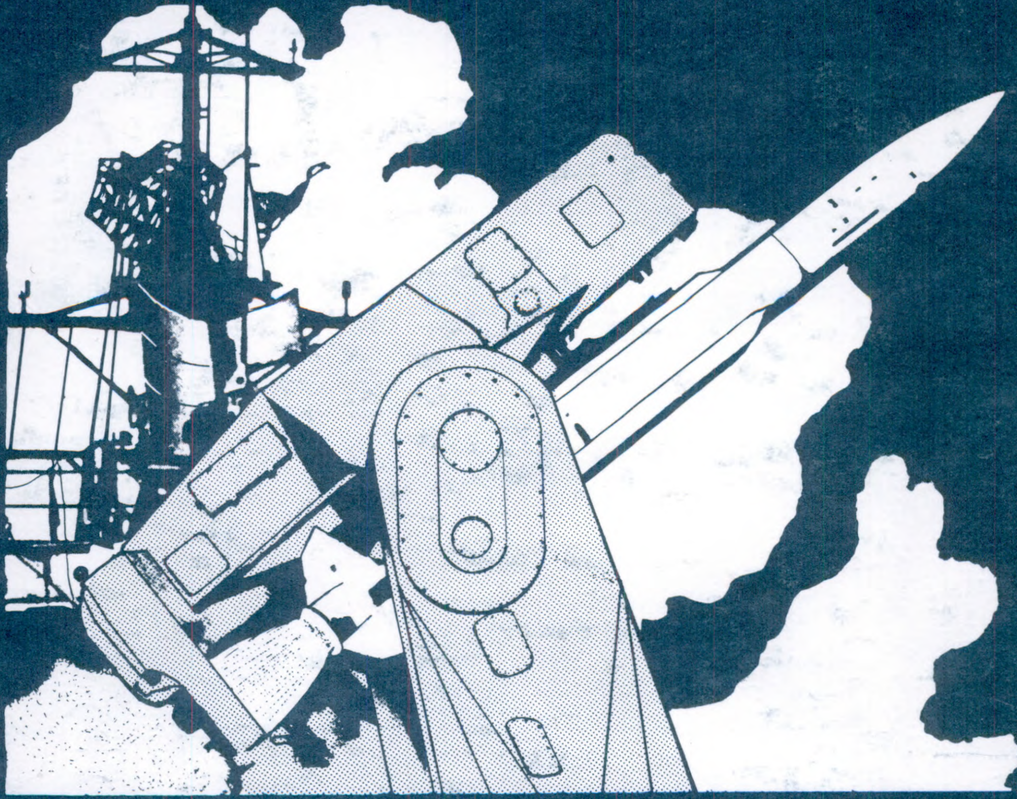

GUNNER'S MATE M 3 & 2, VOL. 2

NAVAL EDUCATION AND TRAINING COMMAND

RATE TRAINING MANUAL AND NONRESIDENT CAREER COURSE

NAVEDTRA 10189

Although the words "he," "him," and "his" are used sparingly in this manual to enhance communication, they are not intended to be gender driven nor to affront or discriminate against anyone reading *Gunner's Mate Missile 3 & 2,* Volume 2 NAVEDTRA 10189.

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Naval Education And Training Program Development Center

GUNNER'S MATE M 3 & 2, VOLUME 2

NAVEDTRA 10189

DEPARTMENT OF THE NAVY ★ CHIEF OF NAVAL EDUC AND TNG ★

1984 Edition Prepared by
GMCS Andrew G. Bixler

PREFACE

This rate training manual (RTM), along with its nonresident career course (NRCC) (NAVEDTRA 10189), is the second of two volumes. The RTM and NRCC together form a self-study package that will help you fulfill the requirements of your rating.

Designed for individual study, the RTM provides subject matter that relates directly to the occupational standards of the Gunner's Mate Missiles rating. The NRCC provides the usual way of satisfying the requirements for completing the RTM. The set of assignments in the NRCC includes learning objectives and supporting items designed to lead students through the RTM.

Gunner's Mate Missile 3 & 2, Volume 1 NAVEDTRA 10188 deals with the construction and working principles of missiles, launching equipment, and their functional components.

This training manual and nonresident career course were prepared by the Naval Education and Training Program Development Center, Pensacola, Florida, for the Chief of Naval Education and Training. Technical assistance was provided by the Naval Sea Systems Command, Washington, D.C.; Naval Sea Center, Atlantic; Naval Ship Weapon System Engineering Station, Port Hueneme, California; and the Gunner's Mate School, Great Lakes, Illinois, whose technical review comments, ideas, and suggestions have been most helpful.

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THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

CONTENTS

CHAPTER Page

9. Guided Missile Weapons Systems........................ 9-1
10. General Maintenance.................................. 10-1
11. Troubleshooting and Testing.......................... 11-1
12. Explosives, Demolition, and Pyrotechnics................ 12-1
13. Small Arms and Machine Guns......................... 13-1
14. Missile Handling and Magazines........................ 14-1
15. Administration and Security.......................... 15-1

INDEX I-1

Nonresident Career Course follows Index

SUMMARY OF
GUNNER'S MATE MISSILES 3 & 2

VOLUME 1 NAVEDTRA 10188

This volume gives a general description of the GMM rating, and the Navy's guided missile systems. It discusses the construction and working principles of missiles, launching equipment, and their functional components.

VOLUME 2 NAVEDTRA 10189

This volume describes missile weapons systems, maintenance and maintenance equipment applicable to missiles and launchers, explosives, pyrotechnics, small arms, magazines, ordnance safety, and administration.

GUNNER'S MATE M 3 & 2 OCCUPATIONAL STANDARDS

NUMBER	OCCUPATIONAL STANDARD	CHAPTER
14 ELECTRONICS MAINTENANCE		
14043	PERFORM PHASE, BALANCE, AND FEEDBACK ADJUSTMENTS TO SERVOAMPLIFIERS	6
14564	INTERPRET COLOR-CODING OF CAPACITORS, RESISTORS, POWER TRANSFORMERS, CHASSIS WIRING AND MULTICONDUCTOR CABLES	10
14565	TEST AND REPLACE PRINTED CIRCUIT BOARDS AND COMPONENTS OF ELECTRONIC EQUIPMENT	10, 11
14567	CONDUCT DAILY SYSTEMS OPERABILITY TEST (DSOT) ON SYSTEMS WITH FIRE CONTROL INTERFACE AND INTERPRET FINDINGS	2, 6, 8, 9
14570	IDENTIFY TYPES AND APPLICATIONS OF ELECTRICAL AND ELECTRONIC CIRCUIT PROTECTIVE DEVICES	4
14798	CHECK ALARMS AND SENSING DEVICES FOR OPERATION	3
15 HYDRAULIC MAINTENANCE		
15023	PERFORM HYDRAULIC TESTS ON ORDNANCE EQUIPMENT	5
15305	INSPECT AND SERVICE HYDRAULIC EQUIPMENT	5, 6, 10
15307	TEST HYDRAULIC ORDNANCE EQUIPMENT; RECORD AND INTERPRET RESULTS	5, 11
15309	INSTALL AND MAINTAIN COMPONENTS IN HYDRAULIC SYSTEMS	5
15311	ANALYZE PUMP MALFUNCTIONS AND MAKE REPAIRS	5, 11
15314	RECOGNIZE TYPES AND PRINCIPLES OF PRESSURE GAGES	5
15315	MAINTAIN PIPES, FITTINGS, SEALS, AND GASKETS	5
16 ORDNANCE AND MISSILE HANDLING		
16022	INSTRUCT CREWS IN TRANSFERRING, HANDLING, AND STOWAGE OF AMMUNITION, PYROTECHNICS, AND EXPLOSIVES	3, 8, 12, 14

NUMBER	OCCUPATIONAL STANDARD	CHAPTER
16 ORDNANCE AND MISSILE HANDLING—CONTINUED		
16027	IDENTIFY TYPES, PROPERTIES, CHARACTERISTICS, FUNCTIONS, AND CLASSIFICATIONS OF EXPLOSIVE ORDNANCE	12
16033	HANDLE AND STOW ORDNANCE AND PYROTECHNICS	3, 12, 14
16034	STOW, ISSUE AND INVENTORY SMALL ARMS AND AMMUNITION	13, 14
16039	PREPARE AERODYNAMIC SURFACES FOR FLIGHT OR STOWAGE	7, 8
16040	MATE AND UNMATE MISSILE/BOOSTER (ROCKET MOTOR)	3, 8
16041	ASSEMBLE AND DISASSEMBLE MISSILES	7, 8
16045	POSITION AND PREPARE MISSILES FOR TESTING	2, 8
16047	PERFORM OPERATIONAL TESTS OF MISSILE HANDLING EQUIPMENT	8
16049	INSPECT, HANDLE AND STOW MISSILE AND ROCKET MOTORS AND ASSOCIATED EXPLOSIVE ORDNANCE MATERIAL	2, 3, 7, 8, 12, 14
16054	HANDLE AND DISPOSE OF HIGH-EXPLOSIVE EXUDATE, POWDERED HIGH-EXPLOSIVE RESIDUE AND DAMAGED EXPLOSIVE COMPONENTS	9, 12, 14
16058	OPERATE AND SERVICE MISSILE-HANDLING AND ASSOCIATED EQUIPMENT	3, 8
16059	OPERATE COMMON AND SPECIAL HANDLING EQUIPMENT APPLICABLE TO NUCLEAR WEAPONS	8
16305	IDENTIFY DUTIES AND RESPONSIBILITIES ASSOCIATED WITH LAUNCHING STATIONS	1, 2, 3, 9
16308	INSPECT AND SERVICE MISSILE LAUNCHING AND MISSILE HANDLING EQUIPMENT	1, 2, 3, 8
16309	OPERATE DEMOLITION EQUIPMENT	12
16392	PACKAGE AND UNPACKAGE NUCLEAR WEAPONS AND COMPONENTS	8
16393	PERFORM PARTIAL STORAGE MONITORING OF NUCLEAR WEAPONS	14

NUMBER	OCCUPATIONAL STANDARD	CHAPTER
16 ORDNANCE AND MISSILE HANDLING—CONTINUED		
16394	MAINTAIN AND REPAIR SPECIAL HANDLING EQUIPMENT FOR NUCLEAR WEAPONS	8
16399	ASSEMBLE AND USE LANDING PARTY EQUIPMENT	13
16400	OPERATE AND MAINTAIN LINE-THROWING GUNS AND ASSOCIATED EQUIPMENT	13
16403	MONITOR AND REPLACE RELATIVE HUMIDITY INDICATORS	14
16404	RECORD MAGAZINE TEMPERATURES AND INSPECT MAGAZINE AREA	14
16405	OPERATE THE FOLLOWING: A. MAGAZINE FIREFIGHTING SYSTEM B. PRP VALVES	3
16407	INSPECT ORDNANCE ITEMS	2, 7, 8, 14
16408	OPERATE PYROTECHNIC EQUIPMENT	12
17 WEAPONS MAINTENANCE		
17063	PERFORM DAILY SYSTEMS OPERATIONAL TESTS (DSOT)	2, 6, 9
17065	MAINTAIN JETTISONING EQUIPMENT AND ALL OTHER ASSOCIATED EQUIPMENT	3
17066	CONDUCT PREFIRING AND POSTFIRING CHECKS	9
17070	INTERPRET RECORDED DATA FROM ALIGNMENT EQUIPMENT AND MAKE ADJUSTMENTS	11
17079	DISASSEMBLE, INSPECT, AND ASSEMBLE: A. PISTOLS, RIFLES, AND SHOTGUNS B. M60, 7.62MM, AND .50-CAL. MACHINE GUNS C. GRENADE LAUNCHERS	13
17081	MAINTAIN LANDING PARTY EQUIPMENT	13
17320	OPERATE MEASURING DEVICES	10
17420	REPLACE DEFECTIVE OR MALFUNCTIONING COMPONENTS AND MODULES	6, 11
17421	INSTALL AND REMOVE ARMING AND FUZING DEVICES	7, 8

NUMBER	OCCUPATIONAL STANDARD	CHAPTER
17 WEAPONS MAINTENANCE—CONTINUED		
17422	INSPECT MISSILE CONNECTIONS, FITTINGS, AND MATING SURFACES	8
17423	INSTALL AND TEST FIRING CIRCUITS FOR DEMOLITION	12
18 TEST EQUIPMENT		
18017	OPERATE MECHANICAL AND ELECTRICAL TEST EQUIPMENT	11
18026	OPERATE LAUNCHING SYSTEM TEST EQUIPMENT	11
24 ELECTRICAL MAINTENANCE		
24023	TEST FOR SHORT CIRCUITS, GROUNDS, AND CONTINUITY OF INTERCONNECTING CABLES AND WIRING BETWEEN COMPONENTS OF ELECTRICAL AND ELECTRONIC EQUIPMENT	11
24025	CLEAN COMMUTATORS AND SLIPRING ASSEMBLIES AND REPLACE BRUSHES	10
24027	REMOVE, INSTALL, ALIGN, AND ZERO SYNCHROS	4, 6
24393	ANALYZE ORDNANCE ELECTRICAL SYSTEMS MALFUNCTIONS	4, 6, 11
24500	CLEAN ELECTRICAL CONTACTS AND SWITCHES	10
24501	PERFORM MECHANICAL WIRE CONNECTIONS INCLUDING SOLDERING	10
24502	DETECT AND REPLACE BLOWN FUSES	4, 11
24503	PERFORM POINT-TO-POINT VOLTAGE AND RESISTANCE MEASUREMENTS	11
24504	TEST AND REPLACE ELEMENTARY ELECTRICAL CIRCUIT COMPONENTS	4, 11
28 TECHNICAL DRAWINGS		
28016	IDENTIFY SYMBOLS COMMONLY USED IN: A. MECHANICAL AND ELECTRICAL DIAGRAMS B. HYDRAULIC AND PNEUMATIC DIAGRAMS, BLUEPRINTS, AND SKETCHES C. ELECTRONIC DIAGRAMS, BLUEPRINTS, AND SKETCHES	4, 5, 6, 11
28019	IDENTIFY ASSEMBLIES AND SUBASSEMBLIES ON DIAGRAMS AND DRAWINGS	11

NUMBER	OCCUPATIONAL STANDARD	CHAPTER
28 TECHNICAL DRAWINGS—CONTINUED		
28020	TRACE CIRCUITS ON SCHEMATICS AND DRAWINGS	4, 5, 6
28025	USE WORKING DRAWINGS IN MAKING REPAIRS, ALTERATIONS, AND MODIFICATIONS	4, 11
28382	USE MICROFICHE, LD DRAWINGS AND READER/PRINTER MACHINES	11
29 MECHANICAL MAINTENANCE/OPERATION-ORDNANCE EQUIPMENT		
29237	CHECK ACCURACY OF TRAIN AND ELEVATION INDICATORS	6, 11
29238	REPAIR DAMAGED SEALING SURFACES, MATING AREAS, AND THREADS	10
29239	REPLACE FAULTY FASTENING HARDWARE AND SEALS	10
29243	TEST AND MAINTAIN: A. MAGAZINE SPRINKLER SYSTEMS B. QUENCHING SYSTEMS C. PRP VALVES	3
29244	CHECK NON-ELECTRONIC SERVOSYSTEMS	11
36 ADMINISTRATION		
36450	MAINTAIN SHOP AND EQUIPMENT WORKLOGS	15
36451	MAINTAIN EQUIPMENT HISTORIES	15
40 FABRICATION AND MANUFACTURING		
40525	CUT, BEND, AND PREPARE PIPING AND TUBING	10
46 PUBLICATIONS		
46030	USE AND MAINTAIN PUBLICATIONS AND INSTRUCTIONS APPLICABLE TO THE OPERATION, TESTING, AND REPAIR OF ORDNANCE EQUIPMENT	1, 11
46426	INTERPRET AND USE NUCLEAR WEAPONS PUBLICATIONS	15
48 MATERIAL CASUALTY CONTROL		
48331	IDENTIFY METHODS AND CURRENT DOCTRINE FOR EMERGENCY FIRING AND DUD JETTISONING	3, 9

NUMBER	OCCUPATIONAL STANDARD	CHAPTER
51 MAINTENANCE PLANNING AND QUALITY ASSURANCE		
51011	COMPLETE MAINTENANCE DATA FORMS FOR: A. COMPLETED MAINTENANCE ACTIONS (MAF) B. DEFERRED MAINTENANCE ACTIONS C. WORK REQUESTS	15
51026	USE MAINTENANCE REQUIREMENT CARDS (MRC)	10
51114	COMPLETE PLANNED MAINTENANCE SUB-SYSTEM (PMS) FEEDBACK REPORTS	15
54 LOGISTICS SUPPORT		
54192	PACKAGE, PROTECT, PROCESS, AND DOCUMENT REPAIRABLE ITEMS FOR TURN-IN	15
54708	SUBMIT DAILY AMMUNITION TRANSACTION REPORTS	15
54759	MAINTAIN CONSUMABLE SUPPLIES AND OBTAIN REPLACEMENTS	15
54760	IDENTIFY CATEGORIES OF MATERIAL CONTAINED IN EACH VOLUME OF COORDINATED SHIPBOARD/SHOREBASE ALLOWANCE LIST (COSAL)	15
54813	CORRECT THE COORDINATED SHIPBOARD/SHOREBASE ALLOWANCE LIST (COSAL)	15
54814	INVENTORY INSTALLED EQUIPMENT AND VERIFY SPARE PART SUPPORT IN COSAL	15
54815	ORDER REPAIR PARTS AND SPECIAL TOOLS REQUIRED FOR INSTALLED EQUIPMENT MAINTENANCE USING COSAL	15
77 SECURITY		
77345	APPLY REGULATIONS GOVERNING CLASSIFICATION AND PREPARATION OF CLASSIFIED INFORMATION INCLUDING: A. RESTRICTED DATA B. FORMERLY RESTRICTED DATA	15
77346	APPLY COMMAND CRITERIA FOR SAFEGUARDING NUCLEAR WEAPONS	14, 15
79 CORROSION CONTROL/MATERIAL PRESERVATION		
79272	APPLY CORROSION PREVENTION AND MOISTURE PROTECTIVE MATERIALS	10
94 MECHANICAL MAINTENANCE		
94424	USE AND MAINTAIN HANDTOOLS	10

CHAPTER 9

GUIDED MISSILE WEAPONS SYSTEMS

The object of this chapter is to provide you with a brief overview of a typical shipboard guided missile weapons system. In doing so, we'll discuss the two remaining topics of the 4-Ds—Detecting units and Directing units. Detecting units are the "sensors" of the ship, such as search radars and sonars. Directing units are part of the fire control community. Their end purpose is to direct and control the ship's weapons to the target. We will concentrate on a guided missile weapons system, but any general descriptions can be applied to gun and ASW systems also.

The operation of a guided missile weapons system is, without doubt, a complex affair. Its success depends on a "team effort" that involves many different equipments and personnel/ratings. To be an effective "player" on the team, today's GMM has to be system-oriented. As a Gunner's Mate, you must have a general understanding of how certain weapons direction and fire control equipments work.

That last point becomes extremely important during weapons system testing. We will introduce the subject of system testing later in the chapter. Additionally, we'll cover two very important pieces of equipment—a training surface-to-air missile (TSAM) and a guided missile training round (GMTR).

NOTE: There are quite a few design variations in weapons system configurations. All equipment descriptions presented in this chapter should, therefore, be interpreted as "typical" examples only.

DETECTION

The first step in a ship's fire control problem is to detect the presence of a "contact." (Note that at this point we use the term "contact," not target.) Once a contact is detected, information about it must be gathered and evaluated. That is the job of personnel assigned to the ship's combat information center (CIC).

A contact can be identified as a friendly, unknown, or hostile in one of three categories—air, surface, or subsurface. Air contacts are often called "bogies"; surface contacts are "skunks." The contact's position is monitored to determine the possible threat it poses to own ship and/or task force. A decision must be made whether to engage the contact and which weapons system to use.

The ship's detection system provides this initial information. The effectiveness of the data is governed by the individual capabilities of the equipment being used. This equipment may be quite sophisticated or very simple. Examples include:

1. Search radars
2. Electronic warfare support measures (ESM)
3. Naval tactical data system (NTDS)
4. Fire control radars
5. Optical devices

The first three equipments listed above are not part of the guided missile weapons system. Nevertheless, they are invaluable sources of initial target information. Sonar was not mentioned, but it is part of the ship's detection equipment. It is also part of the ASW weapons system and functions in both the detecting and directing roles. Further discussions in the text will be limited to above-surface operations.

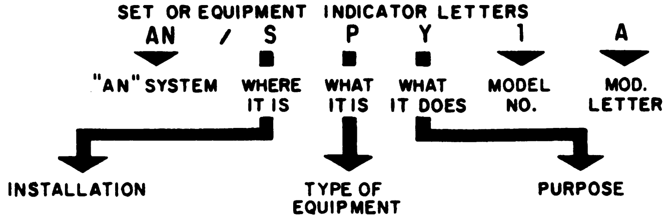
SEARCH RADARS

Search radars are identified by the AN nomenclature system. Figure 9-1 explains the AN system designators which are used to classify Army, Navy, and Air Force equipments. Figure 9-2 illustrates the basic antenna shapes for some of the more popular search radars.

Three-coordinate air search radars are the primary sources of air contact information for a weapons system. The AN/SPS-39, AN/SPS-48, and AN/SPS-52 radars are examples of three-coordinate or dimensional (3-D) radars. They provide precise air search data to the naval tactical data system (NTDS) and/or the weapons direction system (WDS). The data consists of target range, bearing, and height (elevation angle) quantities.

Alternate sources of air contact information are two-coordinate radars. These equipments are the primary means for detecting long-range air contacts. Popular 2-D air search radars are the AN/SPS-29, AN/SPS-37, AN/SPS-40, AN/SPS-43, and AN/SPS-49. They provide coarse range and bearing data only, not height.

Air search radars also incorporate an identification friend or foe (IFF) system. A low-power radio transmitter (the ship's challenging unit) sends a coded message to a contact. If the contact returns a correct response to the challenge, it is identified as a friendly. If the contact fails to return a response or transmits an incorrect response, it is identified as a foe. This aids the ship in evaluating the contact and declaring it a hostile target.



A--AIRBORNE (INSTALLED AND OPERATED IN AIRCRAFT).
B--UNDERWATER MOBILE, SUBMARINE.
C--AIR TRANSPORTABLE (INACTIVATED, DO NOT USE).
D--PILOTLESS CARRIER.
F--FIXED.
G--GROUND, GENERAL GROUND USE (INCLUDES TWO OR MORE GROUND-TYPE INSTALLATIONS).
K--AMPHIBIOUS.
M--GROUND, MOBILE (INSTALLED AS OPERATING UNIT IN A VEHICLE WHICH HAS NO FUNCTION OTHER THAN TRANSPORTING THE EQUIPMENT).
P--PACK OR PORTABLE (ANIMAL OR MAN).
S--WATER SURFACE CRAFT.
T--GROUND, TRANSPORTABLE.
U--GENERAL UTILITY (INCLUDES TWO OR MORE GENERAL INSTALLATION CLASSES, AIRBORNE, SHIPBOARD, AND GROUND).
V--GROUND, VEHICULAR (INSTALLED IN VEHICLE DESIGNED FOR FUNCTIONS OTHER THAN CARRYING ELECTRONIC EQUIPMENT, ETC., SUCH AS TANKS).
W--WATER SURFACE AND UNDERWATER.

A--INVISIBLE LIGHT, HEAT RADIATION.
B--PIGEON.
C--CARRIER.
D--RADIAC.
E--NUPAC.
F--PHOTOGRAPHIC.[1]
G--TELEGRAPH OR TELETYPE.
I--INTERPHONE AND PUBLIC ADDRESS.
J--ELECTROMECHANICAL OR INERTIAL WIRE COVERED.
K--TELEMETERING.
L--COUNTERMEASURES.
M--METEOROLOGICAL.
N--SOUND IN AIR.
P--RADAR.
Q--SONAR AND UNDERWATER SOUND.
R--RADIO
S--SPECIAL TYPES, MAGNETIC, ETC., OR COMBINATIONS OF TYPES.
T--TELEPHONE (WIRE).
V--VISUAL AND VISIBLE LIGHT.
W--ARMAMENT (PECULIAR TO ARMAMENT, NOT OTHERWISE COVERED).
X--FACSIMILE OR TELEVISION.
Y--DATA PROCESSING.

A--AUXILIARY ASSEMBLIES (NOT COMPLETE OPERATING SETS USED WITH OR PART OF TWO OR MORE SETS OR SETS SERIES).
B--BOMBING.
C--COMMUNICATIONS (RECEIVING AND TRANSMITTING).
D--DIRECTION FINDER, RECONNAISSANCE, AND/OR SURVEILLANCE.
E--EJECTION AND/OR RELEASE.
G--FIRE-CONTROL OR SEARCHLIGHT DIRECTING.
H--RECORDING AND/OR REPRODUCING (GRAPHIC METEOROLOGICAL AND SOUND).
K--COMPUTING.
L--SEARCHLIGHT CONTROL (INACTIVATED, USE G).
M--MAINTENANCE AND TEST ASSEMBLIES (INCLUDING TOOLS).
N--NAVIGATIONAL AIDS (INCLUDING ALTIMETERS, BEACONS, COMPASSES, RACONS, DEPTH SOUNDING, APPROACH, AND LANDING).
P--REPRODUCING (INACTIVATED, DO NOT USE).
Q--SPECIAL, OR COMBINATION OF PURPOSES.
R--RECEIVING, PASSIVE DETECTING.
S--DETECTING AND/OR RANGE AND BEARING, SEARCH.
T--TRANSMITTING.
W--AUTOMATIC FLIGHT OR REMOTE CONTROL.
X--IDENTIFICATION AND RECOGNITION.
Y--MULTI-FUNCTION

[1] NOT FOR US USE EXCEPT FOR ASSIGNING SUFFIX LETTERS TO PREVIOUSLY NOMENCLATURED ITEMS.

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Figure 9-1.—The AN system.

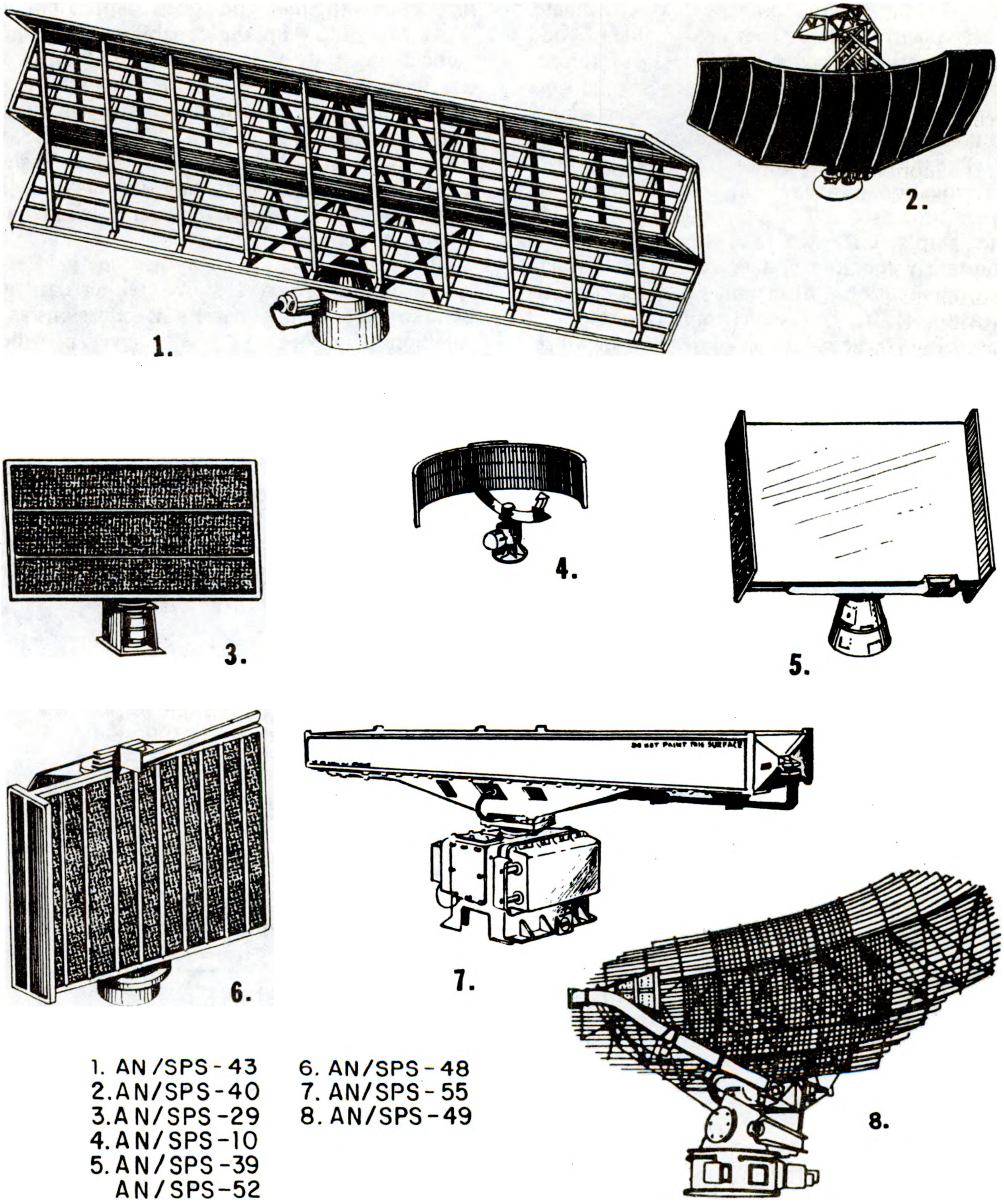

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Figure 9-2.—Search radars.

The AN/SPS-10, AN/SPS-55, and AN/SPS-67 radar sets are short-range, two-coordinate, surface search radars. They are capable of good discrimination in range and bearing of surface contacts and low-flying aircraft. These radars are becoming more important today with their ability to detect low-flying antiship missiles.

The surface and air search data, plus IFF interrogation information, are displayed on operator consoles. These consoles are located in the ship's CIC where assigned personnel constantly monitor and evaluate the contact/target situation. Electronic counter-countermeasure (ECCM) features are available and controlled by the radar consoles. These measures are used to improve console displays when jamming environments are encountered.

ELECTRONIC WARFARE SUPPORT MEASURES

Electronic warfare support measures (ESM) have increased in importance during the last decade. ESM equipment is used to detect, locate, analyze, and record electronic emissions throughout the electromagnetic spectrum. It provides a ship with the capability of gaining tactical and strategic intelligence on all types of enemy electronic activities. These activities may be an enemy radar or an active guidance transmitter of an incoming antiship missile. ESM, therefore, is a vital factor in a ship's defensive ability. ESM also performs its task while remaining undetected by the enemy (similar to passive homing in a sense).

The main piece of equipment in an ESM system is the intercept receiver, either narrow-band or wide-band. It detects RF emissions as a function of frequency. The receiver provides selected signal outputs to console displays, signal analyzers, recorders, and warning devices. The receiver's output may also be used to activate electronic countermeasure (ECM) equipments automatically. These equipments can include electronic deception repeaters and chaff launching devices. The Mk 36 launching system, also known as SRBOC (super rapid bloom offboard chaff), is such a device. Your ship may have one or more

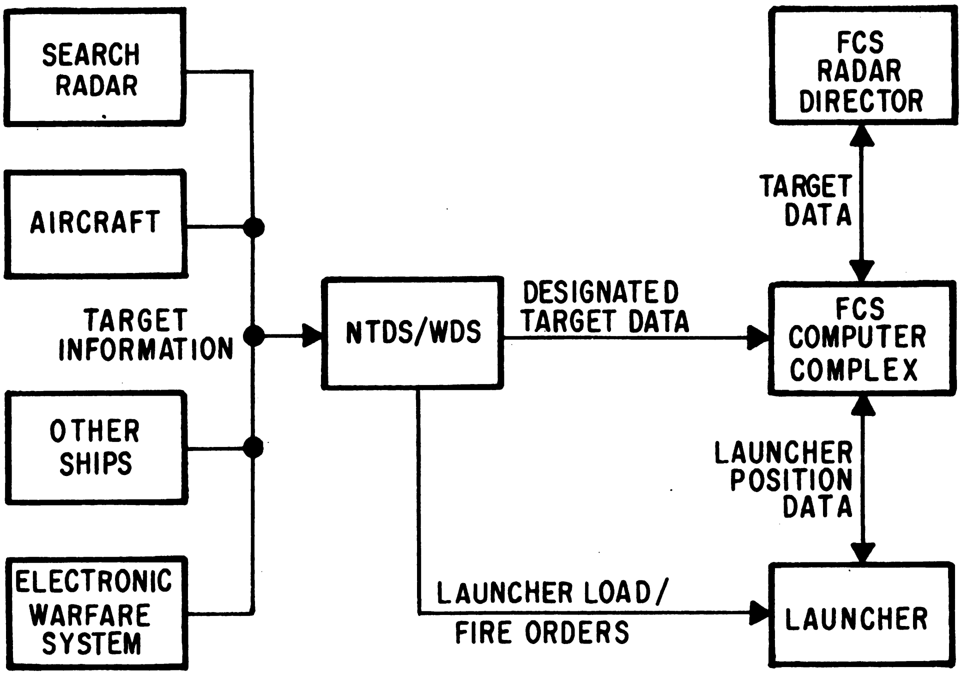

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Figure 9-3.—Typical weapons system; block diagram.

of the following ESM equipments: AN/WLR-1, AN/WLR-3, AN/WLR-8(V), AN/WLR-11A, AN/SLR-12, and AN/SLQ-32(V).

NAVAL TACTICAL DATA SYSTEM

The naval tactical data system (NTDS) is an automatic, high-speed, communication, display, digital-data processing and conversion system. It provides comprehensive tactical data about all types of targets and improves fleetwide defense.

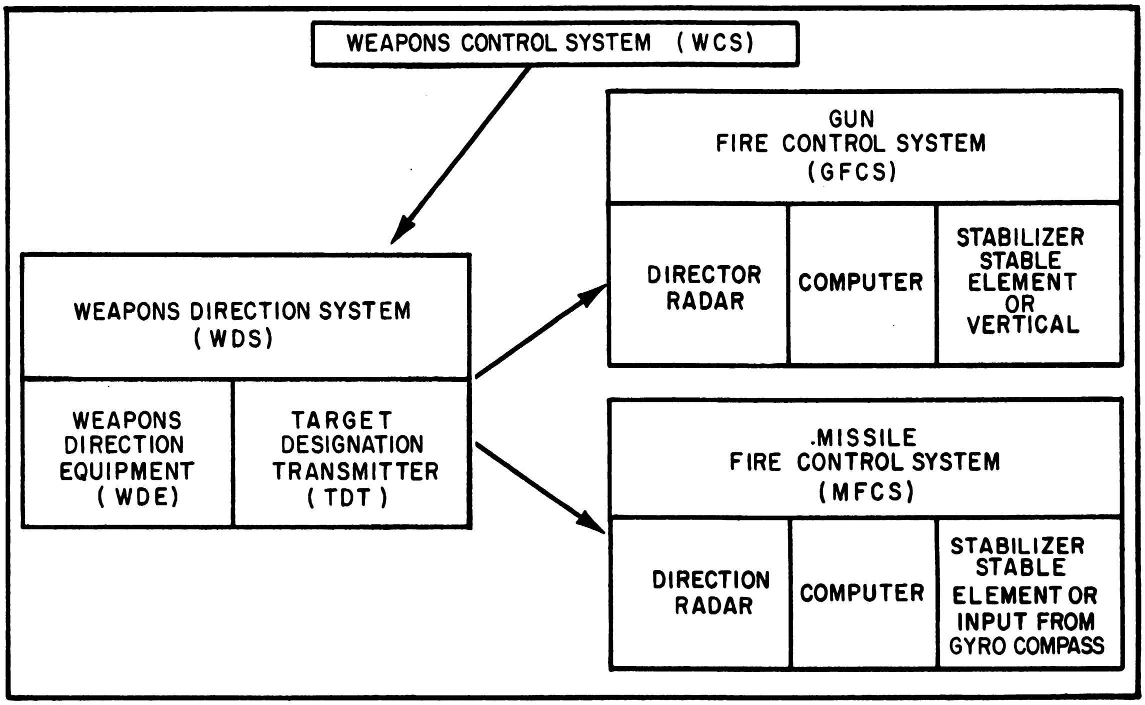
The key word in the previous paragraph was "fleetwide." NTDS coordinates the collection of tactical data from sources both internal and external to own ship. Own-ship (internal) inputs to NTDS are those from search radars, IFF equipment, ESM equipment, sonar, navigation, and communication equipments. External tactical data inputs are received from other NTDS-capable ships, aircraft, and even shore stations. These units can be located many hundreds of miles away. The information about a contact (or many contacts) is transmitted through RF data links. Basically, we have one computer "talking" to another computer.

Own-ship NTDS equipment correlates all data and generates a clear presentation of the overall tactical situation. The decision-making process in CIC (whether to engage a target) is dramatically simplified. NTDS then communicates all action decisions to the WDS.

The general relationship between the NTDS/WDS and other equipments of a weapons system is illustrated in figure 9-3. Block diagrams of other weapons systems (on non-NTDS ships) are fundamentally similar. The principal operational differences are those of speed and reaction time. Non-NTDS ships are inherently slower in processing target data.

WEAPONS CONTROL SYSTEM

The target data accumulated by the detecting units is passed to the directing units. Collectively, the directing units form the ship's weapons control system (WCS). Figure 9-4 illustrates a typical


WEAPONS CONTROL SYSTEM (WCS)
WEAPONS DIRECTION SYSTEM (WDS)
WEAPONS DIRECTION EQUIPMENT (WDE)
TARGET DESIGNATION TRANSMITTER (TDT)
GUN FIRE CONTROL SYSTEM (GFCS)
DIRECTOR RADAR
COMPUTER
STABILIZER STABLE ELEMENT OR VERTICAL
.MISSILE FIRE CONTROL SYSTEM (MFCS)
DIRECTION RADAR
COMPUTER
STABILIZER STABLE ELEMENT OR INPUT FROM GYRO COMPASS

92.12

Figure 9-4.—Makeup of a weapons control system.

WCS, composed of a weapons direction system (WDS) and one or more fire control systems (FCSs).

The main purpose of a WCS is to direct the ship's weapons to ensure maximum kill probability. To do this, the equipments of a WCS perform the following general functions.

1. They receive and process all target information available from the detecting units. This includes target (or targets) location, course, and threat priority.

2. They calculate or compute the predicted line of fire (LOF) so the weapon is fired/launched in the proper direction.

3. They position the delivery unit (gun mount or missile launcher) according to computed (remote) orders.

4. They control the guided missile flight path to ensure target intercept.

The individual equipments of the WDS and FCS "teams" perform these tasks for the ship's WCS.

WEAPONS DIRECTION SYSTEM

A weapons direction system (WDS) consists of three main equipment groups:

1. Weapons direction equipment (WDE)
2. Target designation transmitter
3. Ancillary equipment

Through the combined operation of these equipment groups, the WDS plays a vital role in the functioning of the ship's WCS. The WDS permits centralized control and monitoring of target engagements assigned to the ship's fire control systems. This includes both the gun fire control system (GFCS) and the guided missile fire control system(s) (GMFCS or MFCS).

Weapons Direction Equipment

Most work performed by the WDS is accomplished through its weapons direction equipment (WDE). The WDE is the primary link in the ship's WCS between the detecting units (i.e. search radars) and the FCSs. Once a contact is detected and identified as a hostile target, various decisions must be made. The decision-making process begins at the WDE and is based on target evaluation.

Target evaluation in a tactical situation involves many factors. Consider the few "samples" listed below.

1. What does the target intend to do? Is it going to pass close to the ship for observation purposes only or will it launch an attack? How threatening is the target to the safety of the ship?

2. If an attack is obvious, what kind of weapons can the target launch? How much time is available for a counterattack? What weapon or weapons should be used to repel an attack?

3. In a multiple target attack, which target poses the greatest threat? Which FCS is available to engage the target?

The various units in the WDE present a complete visual picture of the tactical situation. The target evaluation process is performed by ship's personnel with the help of the WDE. The WDE is designed so that each station (console) performs only a part of the overall job. Each partial job is initiated by a preceding act in a systematic schedule of events. Thus, each console operator has a limited number of decisions to make and a limited job to perform. In this way, target data are handled efficiently and with minimum delay.

WDE installations vary, but the major units and their functions are similar. The main units of a typical WDE are:

1. Target selection and tracking console (TSTC)

2. Director assignment console (DAC)
3. Weapons assignment console (WAC)

TARGET SELECTION AND TRACKING CONSOLE.—The target selection and tracking console (TSTC) is shown in figure 9-5. It receives inputs from a search radar and produces a plan position indicator (PPI) and target height display. This display depicts the tactical situation about own ship as seen by a search radar. From the display, an initial evaluation of target threat is made. The range and bearing coordinates of threatening targets are inserted into automatic tracking channels. Successive target position inputs to each channel are used to calculate and correct target range and bearing rates. Each tracking channel provides a continuously generated target position in these quantities. Target height, when measured by a three-coordinate search radar, is also inserted in the tracking channel and memorized.

The tracking channels on the TSTC are identified by letters. There is provision for six channels, lettered A through F. Numerals that appear on the PPI identify FCSs that are tracking targets. Targets being tracked in the TSTC tracking channels are normally forwarded to the director assignment console (DAC) for further processing.

Most installations have more than one TSTC. Normally, one console is used for selecting targets and the others for tracking targets. Each console, however, has the same display. By having more than one console, the operational burden and the decision-making requirements of each operator are reduced. Remember, when handling target data, time and accuracy are important. Identification of targets is normally handled by the CIC, but the TSTCs have IFF challenge controls to permit last-minute identification. In an emergency, a TSTC can designate directly to the FCSs. For this reason, the positions of the FCS directors and the clear bearing zone for missile firing are available for display. In normal operation, however, clear bearing zone is not displayed.

DIRECTOR ASSIGNMENT CONSOLE.—The main purpose of the director assignment

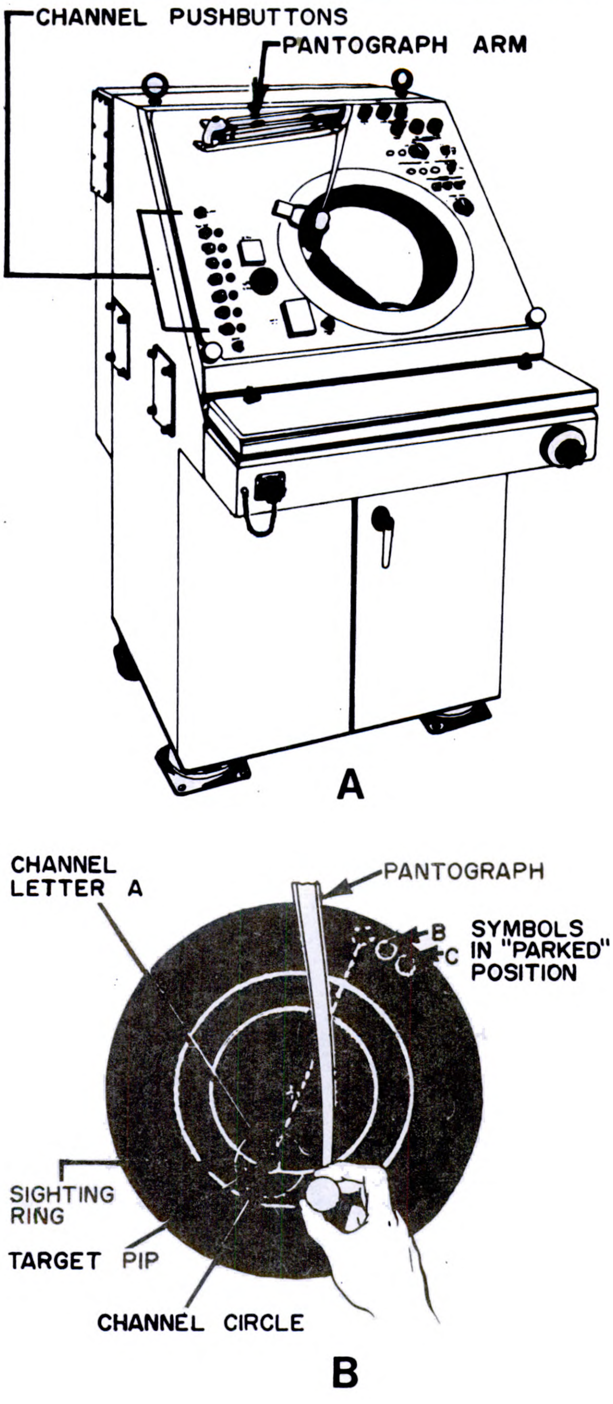


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Figure 9-5.—View A—a target selection and tracking console (TSTC); View B—the TSTC's plan position indicator (PPI).

console (DAC) is to determine the order of target engagement according to relative threat. The DAC operator assigns an FCS to a target, based on the FCS's suitability and availability. The DAC operator can also transfer target data from one FCS to another. This is called interdirector designation or IDD. To obtain a better line of sight between the FCS radar and target, the DAC operator can recommend ship course changes.

All targets being tracked in TSTC tracking channels are displayed on the DAC's PPI. This PPI is known as the plan plot (view A of figure 9-6). The presentation provides the DAC operator with many evaluation aids. Examples include target present position, target predicted course, and range rings. Own ship heading and clear firing zone lines are also provided.

A second display, called the multipurpose plot (view B of figure 9-6) provides more evaluation data. Target height, target speed, and time factors for each target in a tracking channel are presented. Although this information is primarily intended for the missile system, it also provides good approximations for gun system engagements.

The DAC operator uses all the evaluation aids/displayed data to determine which FCS to assign to a target. Once the decision is made, the DAC designates target coordinates to a GMFCS or GFCS.

WEAPONS ASSIGNMENT CONSOLE.—The main function of the weapons assignment console (WAC) is to perform the final evaluation of a target. The WAC (figure 9-7) is the primary link between the GMLS and the WDS. Launcher loading, assignment, and missile firing are some of the major events controlled by the WAC operator.

A PPI for each GMFCS displays target bearing and range. A ring on the PPI indicates

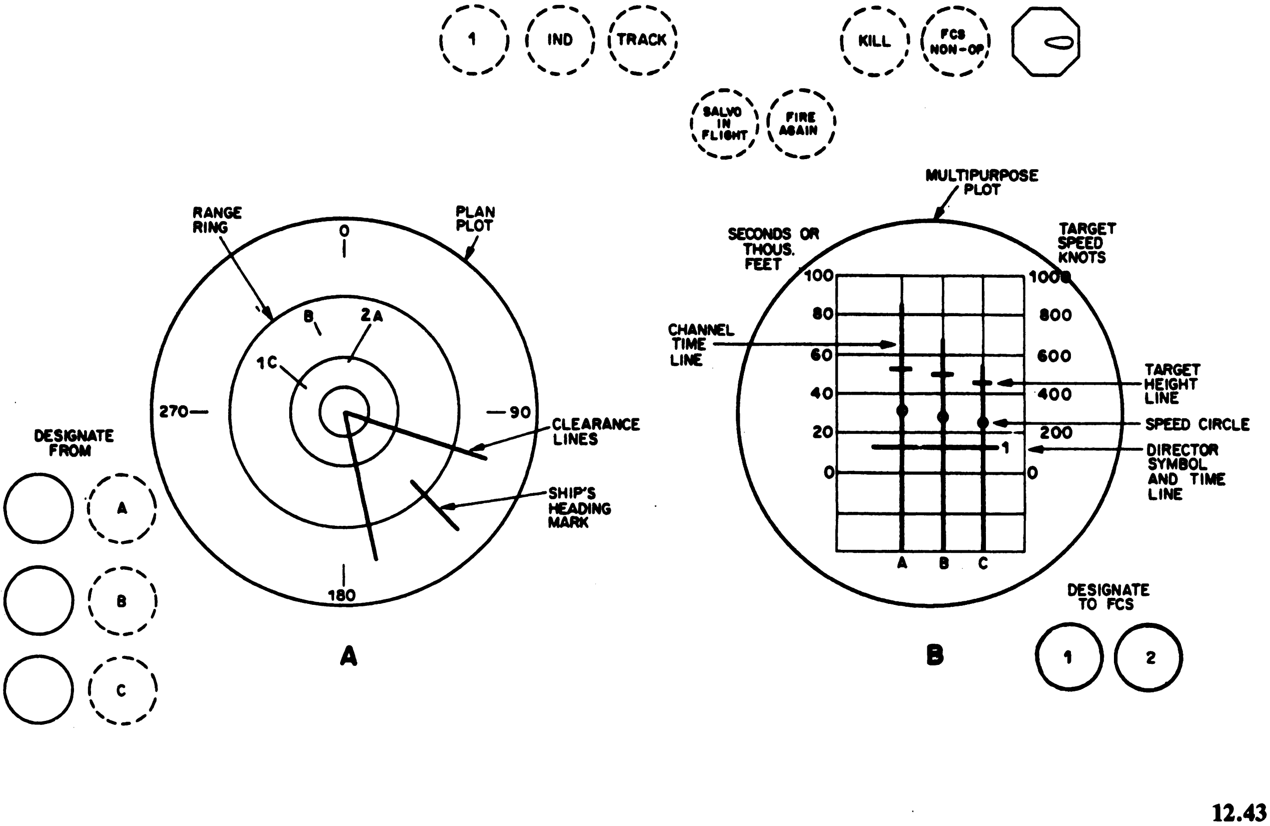

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Figure 9-6.—Director assignment console (DAC) display: A. Plan plot; B. Multipurpose plot.

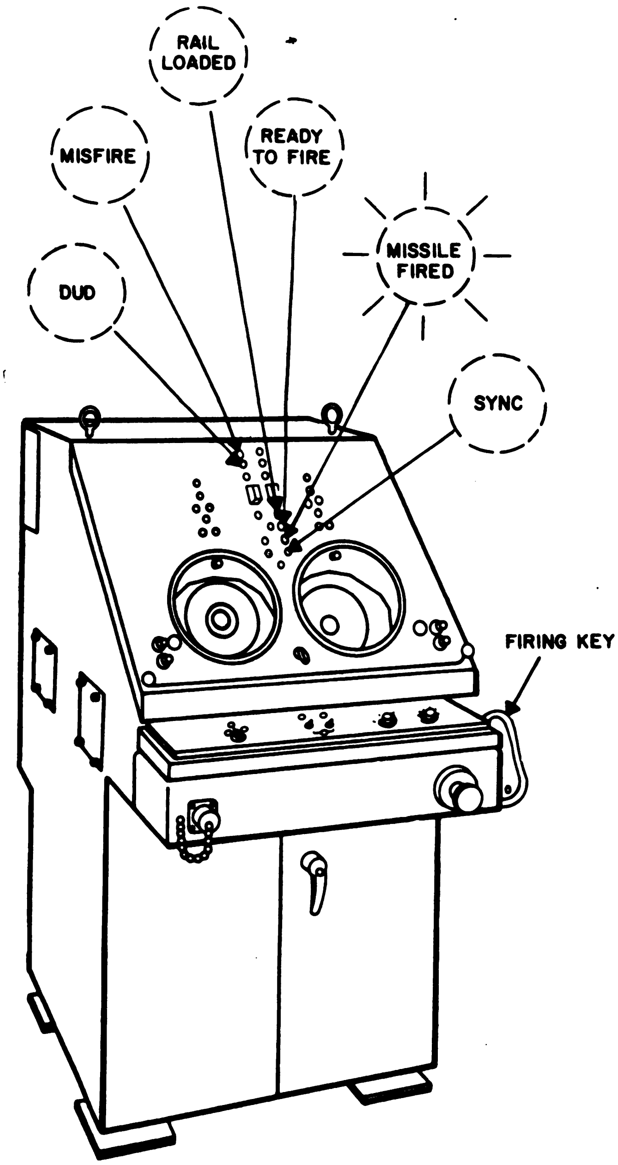

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Figure 9-7.—Weapons assignment console (WAC).

maximum missile effective range. The target predicted intercept point is also displayed, along with clear fire zones and own-ship heading.

Indicator lamp rows above the PPIs provide a complete sequential display from rail-loaded through salvo-in-flight events. The missile firing key is mounted on the WAC. When the key is closed by the WAC operator, the ITL signal is initiated. Should the normal firing circuitry fail to launch the missile, the WAC operator can start auxiliary firing procedures.

Target Designation Transmitter

Located high on the ship's superstructure at the AAW station are four pieces of WDS equipment. One target designation transmitter (TDT) and its control unit are on the port side, another TDT and its control unit are on the starboard side. (See figure 9-8.) Each piece of gear is manned by an operator.

A TDT is a manually controlled, optical-sighting unit. The TDT operator tracks a target using binoculars mounted on the transmitter. The operator closes a switch on the handgrip to signal that the TDT is on target and tracking. Target bearing and elevation information is transmitted to the control unit. Estimated range is manually cranked into the control unit by its operator.

Target data are normally transferred to the DAC for display. The DAC operator evaluates the situation and assigns the appropriate FCS (GMFCS or GFCS). The TDT can also designate directly to an FCS (bypassing the DAC) if target engagement time is limited.

Ancillary Equipments

The ancillary equipments of the WDS are primarily status indicators, transmitters, processors, and applicable power supplies. These equipments are located throughout the ship and perform a variety of minor functions.

One such example is the casualty weapons direction panel (CWDP). It is located in the GMFCS radar control room. The CWDP performs many of the same basic functions common to the DAC and WAC. Should they become inoperative, the CWDP could be activated and operations may continue in a casualty mode.

FIRE CONTROL SYSTEM

A fire control system consists of two major equipment groups:

1. Fire control radar set
2. Computer complex

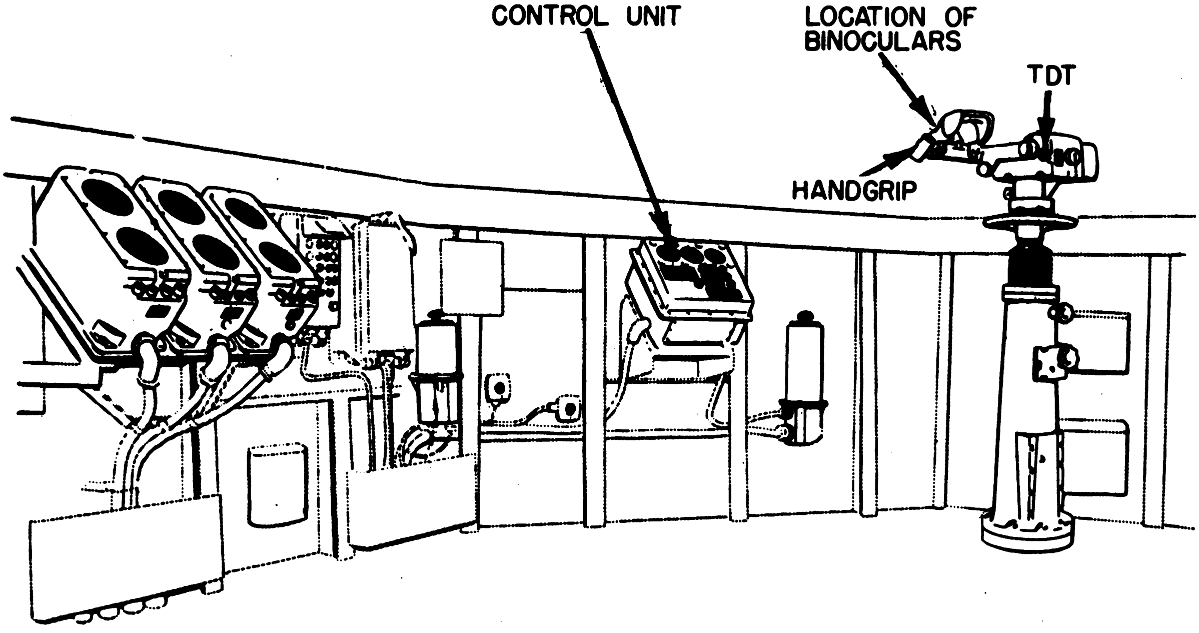

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Figure 9-8.—Target designation transmitter (TDT) and control unit; starboard side only.

Bear in mind, most ships will have more than one FCS. Typically, there will be one GFCS and two (maybe up to four) GMFCSs. To distinguish between FCSs, they are assigned a number based on forward-to-aft shipboard location (i.e., FCS 1, FCS 2). A GMFCS is capable of performing the following operations:

1. Automatically acquiring and tracking designated targets.
2. Determining the range, range rate, bearing, elevation, and angular error data of the target.
3. Providing illumination of the target for missile guidance.
4. Engaging in preprogrammed search modes.
5. Generating rates to maintain the director and radar set on target during tracking.
6. Providing tactical display data of the WDE.
7. Generating launcher rate and positioning orders.
8. Generating missile preflight orders.
9. Supplying internal test and exercise data for weapons system testing.

The above list only highlights a few of the major FCS functions. Did you notice that many of these operations directly affect the GMLS and guided missile?

Radar Set

A typical missile fire control radar set is illustrated in figure 9-9. The set consists of an antenna group and a control and power group. The antenna group is located above deck. It consists of a pedestal (director) which mounts the radar antenna (commonly called a dish). Electromechanical power drives position the director and antenna in response to FCS computer-generated train and elevation orders. Additionally, the antenna (and thus the transmitted radar beams) are space-stabilized. Rate gyros are used to generate stabilizing orders to compensate for the roll and pitch of the ship. This maintains an accurate line of sight (LOS) between the radar and the target.

The control and power equipments are located below deck in a compartment called the radar control room. This room contains the consoles

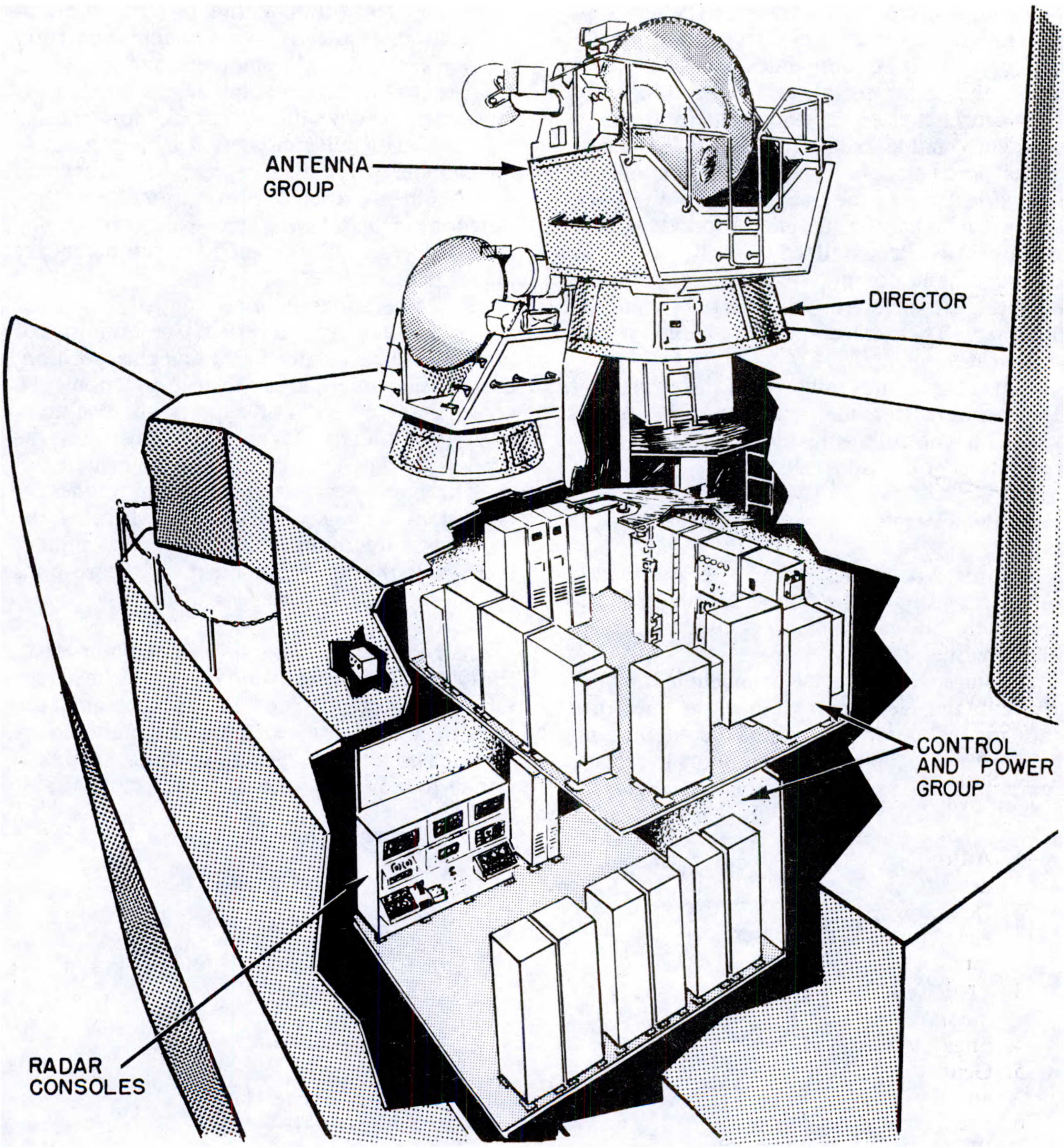

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Figure 9-9.—Guided missile fire control radar set; above- and below-deck equipment groups.

used to operate, monitor, and control the radar set(s). Nearby are the electronic cabinets containing power supplies, transmitters, receivers, and related microwave circuitry.

When the DAC designates a GMFCS to a target, the radar set slews to the designated coordinates. After a brief search pattern, the radar set acquires and locks on the target. FCS tracking begins and circuits within the radar set automatically keep the tracking beam on target. Range, bearing, and elevation data are continuously transmitted to the GMFCS computer. The computer and radar set work together to solve for the target's rate of movement. These calculations are based on line-of-sight movements.

The radar set not only tracks the target, but also transmits RF guidance beams. These beams are used to control the missile in flight and guide it to intercept.

Computer Complex

The missile computer complex is the second equipment group in the GMFCS. The computer is normally located in a below-deck compartment called missile plot.

A computer is a device or machine in which physical or electrical operations perform mathematical computations. The computations then provide logical or numerical results. Computers are usually classified as analog or digital. Analog computers deal with the continuous measurement of a function. Digital computers deal with counting discrete values of a function. Basically, the analog computer measures, the digital computer counts.

Although analog computers were once the most common types in fire control, they are being replaced by digital computers. Digital computers are capable of a higher degree of accuracy and solve problems faster. However, some computing functions in digital systems are still performed by analog devices. All current SMS computers are digital devices.

The operations a fire control computer performs are many and varied. Computations of lead angle, radar repeatback, launcher position, and missile orders are the basic functions. To arrive at these results or outputs, the computer needs input data. Figure 9-10 illustrates the general flow of data relative to the computer.

The computer has three major modes of operation—air ready, designate, and track. The following paragraphs describe how the computer works with the other components of the weapons system in these modes.

AIR READY MODE.—The computer places the GMFCS in air ready mode before or between target engagements. The GMFCS is energized but is not tracking or receiving a designation alert signal. The computer generates control and data signals to move and/or hold the director at its air

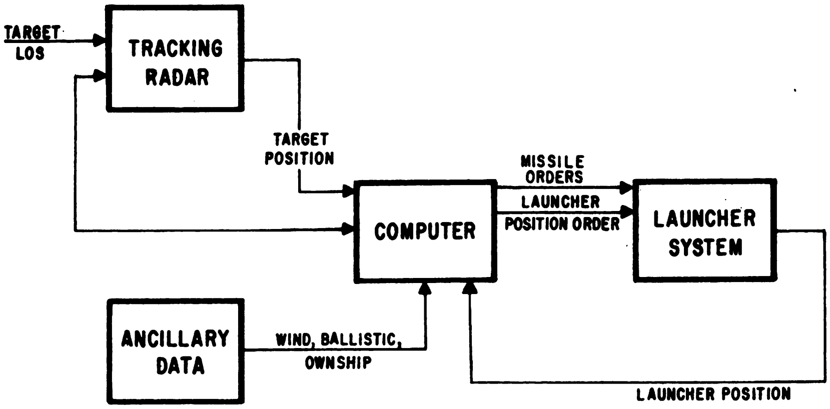

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Figure 9-10.—Computer input and output data flow.

ready position. This is usually 0° or 180° train relative bearing (like stow position for a launcher). Radar (transmission) range is also at its air ready value.

DESIGNATE MODE.—After a contact has been evaluated to be a threat, the DAC operator designates (assigns) the target to an FCS. When the missile computer receives the designation alert signal, it places the GMFCS in designate mode. The computer accepts all target position data from the DAC. This information is processed to generate director positioning orders. The director responds by slewing toward the designated target location. The radar range is also made to drive out to the designated position.

The computer may generate a search program to aid the radar in acquiring the target. The search program modifies the designation data to the director. This causes the radar beam to sweep in a pattern about the designated position. Figure 9-11 shows what these patterns may look like. The type and size of search pattern are determined by the accuracy of the designated data. That is a factor of the designation source and its reliability.

TRACK MODE.—Once the radar receives a predetermined number of target echo returns, the search program stops. The computer sends the director back to where the most target echoes occurred. The radar then locks on the target and transmits a tracking or locked-on signal to the computer. After this signal is maintained for a predetermined interval, the computer generates an on-target signal. This places the GMFCS in the track mode.

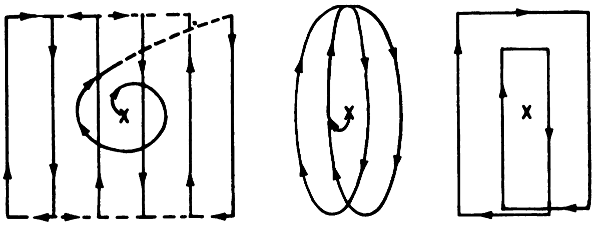

Figure 9-11.—Search patterns.

Target tracking is accomplished through a closed loop consisting of the radar, director, and computer. The radar senses the angular errors between its antenna RF axis and the target's position. These errors, along with range and rate data, are transmitted to the computer. The computer makes up the relative motion rates to keep the director on target.

During the track mode, the computer is also providing services for other equipments of the weapons system. Tracking data are transmitted to the WDE and are displayed on the various PPI scopes. The TSTC, DAC, and WAC operators use this information for further target evaluations. Additionally, the computer is preparing launcher position orders and missile preflight orders. These signals will be transmitted to the GMLS at launcher assignment.

MISSILE CONTROL

Once the GMFCS is in the track mode, the fire control "problem" is essentially solved. The remaining operations of the WCS involve putting the solution into effect. A majority of the events described in the following paragraphs are initiated at the WAC. The GMFCS, GMLS, and missile receive orders and respond.

Missile Selection

Based on target evaluation data, the WAC operator selects the type of missile to be launched. The GMLS responds by moving the selected missile into position for loading. For dual-arm GMLSs, the WAC operator must also select A-only, B-only, or A and B operations.

To load the selected missile(s) to the launcher, the WAC operator selects load-once or load-continuous. The GMLS responds by performing an automatic load cycle and provides the launcher-to-missile connection.

Launcher Positioning

The launcher points the missile along the computer-determined line of fire (LOF). As the target approaches the predicted intercept point, the WAC operator assigns the launcher to the tracking GMFCS.

Dual-speed synchro control signals cause the launcher to drive to the ordered position. Director velocity (d.c. rate) signals keep the launcher on position. The launcher synchronizes with the remote orders and follows them as long as the assignment is in effect.

Actually, the launcher elevation angle is slightly greater than that required for a collision course. This higher launch angle places the missile in a rarefied atmosphere early in flight. It conserves flight velocity and achieves a missile descent during the final phase of flight. The end result is an improved tactical performance.

Missile Orders

To carry out its mission, the guided missile needs information. This information may be supplied before and/or during flight. Right now we are concerned with preflight orders. These signals are in the form of various voltage values. They are supplied to the missile by the GMFCS through the launcher-to-missile contactor. Missile orders are applied at launcher assignment and are continuously updated until the time of firing.

Missile orders vary from system to system and between missiles. The following paragraphs describe a few of the more common orders and their function.

MISSILE ROLL ORDER.—While on the launcher, the missile's vertical axis may rotate (tilt) due to the ship's motions. If the missile were fired with its vertical axis tilted, missile gyros would maintain this position or false axis. A target miss could result.

The fire control computer monitors ship motions. Before the missile is launched, the computer transmits a roll correction or roll order signal. This signal causes the missile's vertical axis to return to its true attitude after the missile leaves the launcher.

SEEKER ORDERS.—Guided missiles are launched along a predicted line of fire. This launch path does not point the missile (nor its seeker head signal antenna) directly at the target. Something must be done to enable the missile to receive reflected RF energy from the target. The easiest solution is to turn the signal antenna toward the general target area.

Seeker orders, also known as head orders, are applied to the missile before launch. They cause the signal antenna to turn toward a predicted point in space. This point represents where the target should be at the end of the missile's boost phase. Actual antenna positioning may occur just before or just after launch.

VARIABLE NAVIGATION RATIO.—To intercept high-speed air targets, homing missiles must follow a lead (or collision) course. If the target flies a straight-line, constant-velocity course, the missile can also follow a straight-line collision course. However, that is hardly the case. The target may turn away or perform evasive maneuvers. Wind gusts and irregular propellant burning affect the missile's trajectory and velocity.

SMS missiles use a proportional navigation flight path that is actually a refinement to a collision course. It compensates for any changes in target and missile trajectories. If the missile-to-target line of sight (LOS) rotates (changes) (figure 9-12), the missile's guidance and control systems order a turn. The steering correction is in a direction to reduce the LOS rotation to zero.

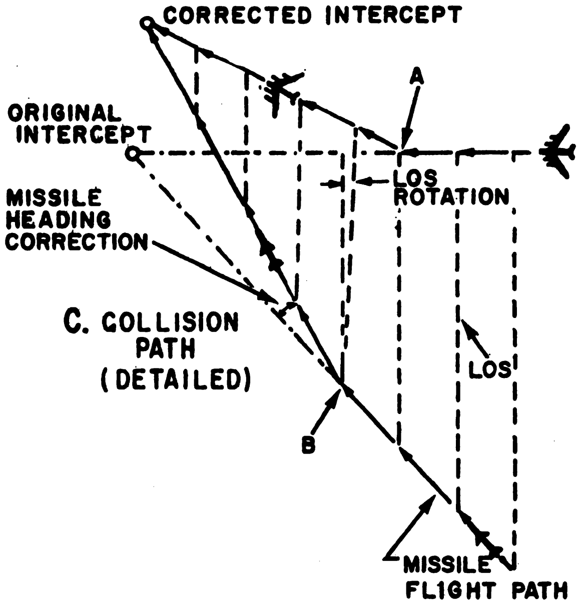

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Figure 9-12.—Collision course modified by proportional navigation.

It is also performed at a rate proportional to the angular rate of change of the LOS. This proportional correction is the navigation ratio, which is really missile steering system gain. It determines the rate at which the missile turns for any given error signal.

To increase the missile's kill probability, the proportional navigation course is modified slightly. This is done by a variable navigation ratio (VNR) signal. VNR is generated by the fire control computer and applied to the missile prior to launch.

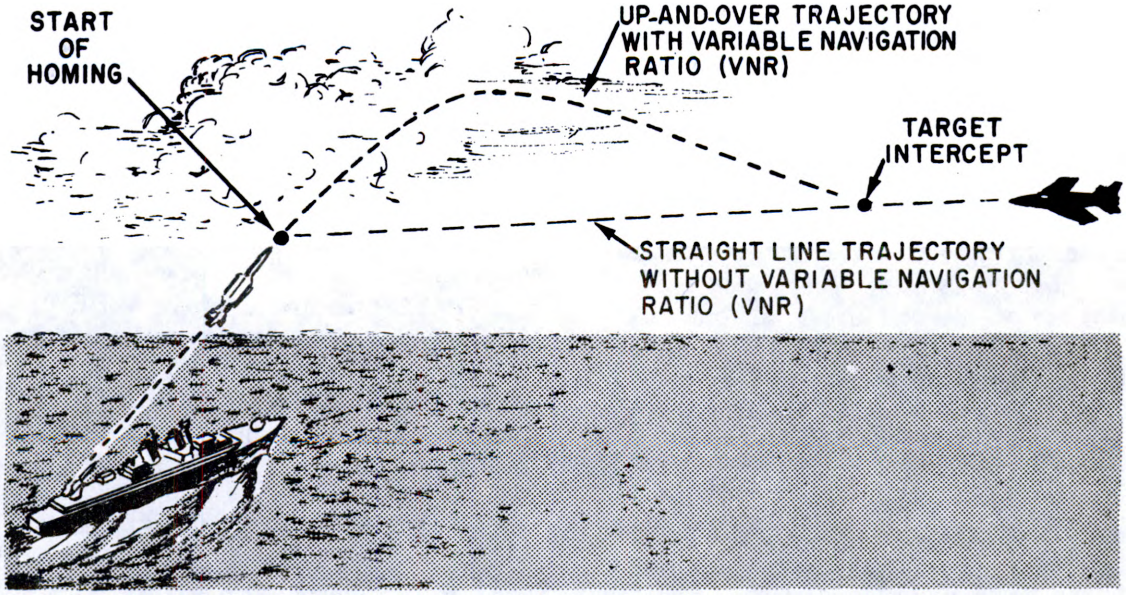
The VNR signal reduces the steering gain of the missile during the early part of flight. This low steering gain, plus the superelevated launch angle, permits the missile to ascend to a high initial altitude. In the rarefied atmosphere, the missile experiences less aerodynamic drag.

After reaching the higher altitude, the missile gradually turns (through VNR) toward the target. It then plunges downward toward the point of intercept (figure 9-13). This action preserves the high missile velocity acquired during boost. It also provides the missile with greater maneuverability during the terminal phase of flight.

DOPPLER PREDICT.—During flight, guidance information is derived by the missile in the form of Doppler. Doppler, or the Doppler principle, pertains to the shift or change in frequency of a series of energy waves. This shift occurs when there is relative motion between a sending source and a receiving point.

A simple example of Doppler, in terms of sound waves, is the change in pitch of a train whistle. As the train approaches, passes, and moves away from a stationary observer, the pitch (or frequency) of its whistle changes. These frequency changes are examples of a Doppler shift. The train is the sending source and has relative motion in respect to a stationary observer's ear, the receiving point. The change of frequency can be measured to determine the speed of the train.

In a guided missile, the frequency shift is between the RF reflected signal and the RF reference signal. The reference signal is received directly from the FCS illuminating radar. The difference between these two signals represents the missile-to-target closing range rate.


START OF HOMING
UP-AND-OVER TRAJECTORY WITH VARIABLE NAVIGATION RATIO (VNR)
TARGET INTERCEPT
STRAIGHT LINE TRAJECTORY WITHOUT VARIABLE NAVIGATION RATIO (VNR)

167.887

Figure 9-13.—Effects of variable navigation ratio (VNR).

The Doppler predict signal is provided to the missile by the fire control computer. Based on tracking data, the signal is proportional to what the missile-to-target closing rate should be. The Doppler predict signal determines the RF frequency at which the missile's receiver starts searching for the target's Doppler (reflected) signal.

WCS OPERATIONAL PHASES

The following areas of the text will summarize the major operational phases of a WCS. Bear in mind the object of this chapter—to present a brief overview of a "typical" shipboard WCS. Our examples centered around non-NTDS equipments, such as those in figure 9-14. Much of the data displayed by these machines had to be handled manually. Target evaluations were the result of a human thought process.

Newer WCSs, coupled with an NTDS or Aegis system, are much more sophisticated. Contact and target data are handled by computers, with very little human factor involved. However, whether old and manual or new and computerized, the basic operation of a WCS is similar. The purpose of any WCS is to control the delivery of a warhead to a target.

TARGET DETECTION PHASE

The target detection phase is always the first phase of operation. It involves the detection and discrimination of contacts that appear within the surveillance field. This detection is normally performed by air or surface search radars. Sonar and ESM are two other sources. In some cases, the FCS radars and even the TDTs can be used as detection elements.

TARGET CLASSIFICATION PHASE

This important operational phase classifies a contact. Electronic IFF equipment is used to challenge and identify a contact friend or foe. However, there are situations where verbal (radio) communications or visual observation methods are used.

TARGET LOCATION PHASE

The target location phase consists of locating the target with sufficient accuracy for weapons deployment. Search radars provide coarse range, bearing, and (sometimes) height data. The WDS designates a GMFCS to the general target area. The GMFCS radar searches, acquires, locks on, and tracks the target. The radar set obtains precise target data at this time and relays the information to the GMFCS computer. The computer processes the data and provides the solution to the fire control problem.

MISSILE SELECTION PHASE

This phase involves selecting the best missile for a particular job. For example, SM-1A (MR), SM-1 (MR), and Harpoon missiles are all surface-capable weapons. However, if the target is a ship over the horizon, many miles from own ship, Harpoon is the best choice. The same logic applies for air targets. Consider a Terrier weapons system with SM-1 (ER), SM-2 (ER), and BT missiles in its arsenal. Each weapon has its own unique characteristics. The tactical situation determines the best missile to use.

MISSILE LAUNCHING PHASE

The missile launching phase is the Gunner's Mates' bread and butter. We won't repeat all the things that happen in this phase of operation. The first eight chapters of this manual have said it all (almost)!

One point to bring out, though, is communications. A free, open, and proper line of communications must be established between the GMLS operators and the WDE personnel. Simply put, talk to each other. Before that firing key is closed, the left hand must know what the right hand is doing. Don't chatter on sound-powered phone circuits, but pass on vital information and keep everybody informed.

MISSILE GUIDANCE PHASE

The last phase of operation starts with the application of selected preflight missile orders and ends with warhead detonation. In between, all methods of guidance for trajectory and attitude

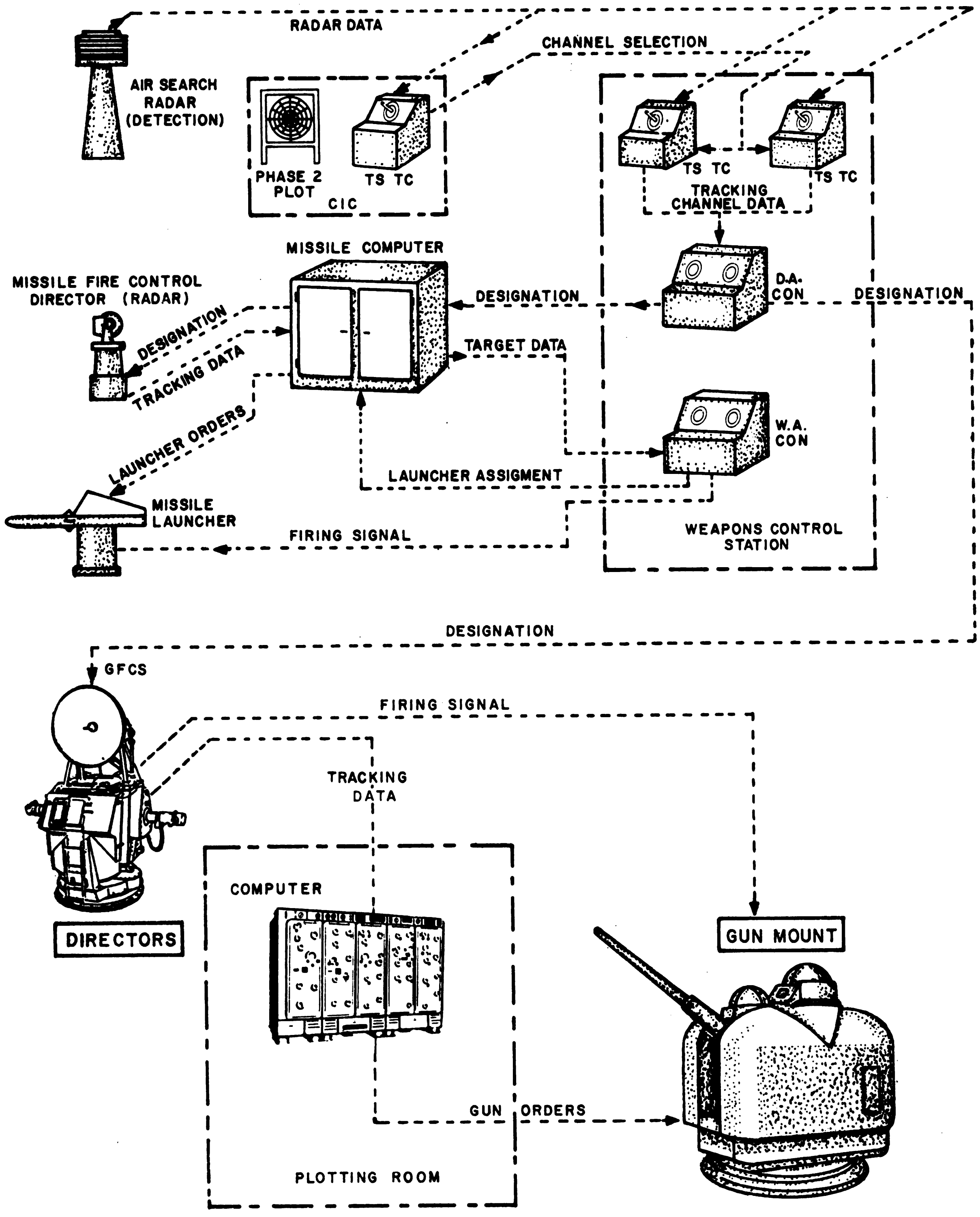


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Figure 9-14.—Simplified data flow in a typical shipboard weapons system.

control are used. Through the boost, midcourse, and terminal phases of flight, the missile is constantly closing on the target.

PROBLEM SEQUENCE

We have just covered the basic sequence of operations in a fire control problem. Refer to figure 9-15 as we plot these events against a time base.

Detection operations are taking place during the period between T-1 and T-2. This time varies depending upon the complexity of an engagement and the operating conditions at the time. T-1 represents the time that target information is first disclosed. During detection, the target's approximate position is established and initial evaluation takes place. This evaluation includes considerations such as whether the target is hostile or friendly and the degree of threat.

Designation occurs between T-2 and T-3 and it is a relatively short period. It represents the time it takes to position the tracking radar to the approximate position of the target.

Acquisition, between T-3 and T-4, takes place after the tracking radar has accepted designation data from the detection source. Because of the narrow beam from the fire control tracking radar, it may not see the designated target. The tracking radar scans a volume of space around the designated point in space. This should result in acquisition of the target and cause the tracking radar's automatic tracking circuits to come into operation.

T-4 represents the time that automatic tracking starts. At this time, accurate target data are transmitted from the tracking radar to the fire control computer. Based upon these target data, the computer begins solving prediction and launch data. The prediction data are transmitted to the WDS for a final evaluation of the target's engageability. Launch data computations provide launcher position data. These remote orders are transmitted to the launcher when it is assigned to the appropriate fire control system.

Evaluation of a target's engageability continues until the determination has been made to fire. At this time, T-5, the firing key is closed to initiate the prelaunch phase of operations. During prelaunch, the missile is brought to a flight operational status. The missile transmits a MISSILE READY indication when the missile firing circuits are completed. Then ignition of the missile booster squibs takes place. The missile

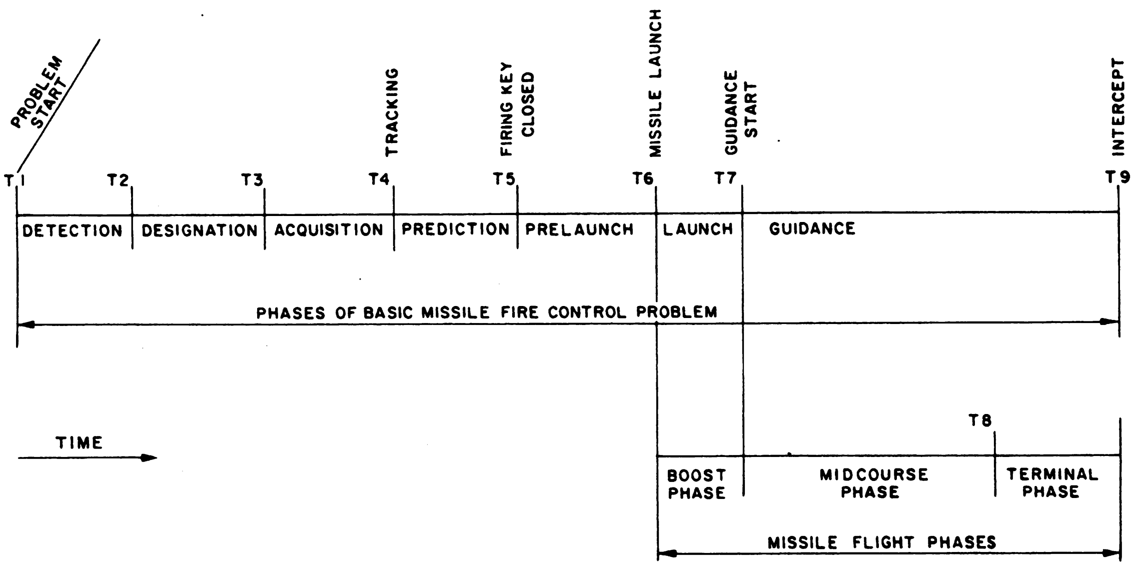

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Figure 9-15.—Problem sequence.

booster ignites and launch occurs at T-6. Prelaunch operations normally involve less than 2 seconds of time.

The launch phase of our problem corresponds to the boost phase of missile flight. During this period the missile is in flight and on its way to a point in space. The missile seeker head will slew toward and acquire the target. The missile is then controlled by guidance signals, either from within or from an external source.

During launch, the missile control surfaces may or may not be activated. If activated, they are striving to maintain missile stability during the boost phase. You can look at this as a form of missile guidance. However, for our problem, guidance is going to begin at T-7, shortly after booster burnout or separation. The time between T-6 and T-7 (boost) may vary from .5 second to between 4 to 7 seconds, depending on the missile. Midcourse guidance (T-7 to T-8) is in effect until the terminal phase begins. The time duration of total guidance (T-7 to T-9), assuming a constant missile velocity, is dependent upon intercept range.

WEAPONS SYSTEM MAINTENANCE

In today's SMS fleet, the name of the game is readiness. Is the weapons system ready IN ALL RESPECTS to engage a target successfully? To achieve the optimum state of readiness, the weapons system must be maintained and tested.

At the equipment level, the gear (i.e., GMLS, computer, radar set, etc.) must be lubricated, aligned, and checked. This ensures individual accuracy and reliability. These general maintenance tasks are performed by the technicians assigned to the various work centers. (The next chapter discusses general maintenance in greater detail.)

At the system level, maintenance actions are concerned with alignment and electrical operability testing. The maintenance responsibility shifts to all personnel assigned to the missile division. In short, a team effort is required. Normally, the missile Fire Controlmen assume the lead in system maintenance actions. However, Gunner's Mates are equally involved.

SYSTEM TESTING

To determine the readiness of the missile weapons system, a series of tests has been developed under the SMS program. These tests are known as system maintenance tests (SMTs). They are used to evaluate the ability of a weapons system to perform effectively. If SMTs uncover a problem, corrective action is required. Quite often troubleshooting must start at the system level. It then works its way down to the individual piece of equipment at fault.

SMTs, in conjunction with separate equipment level tests, provide a thorough check of the entire weapons system. The tests are designed (for the most part) not to overlap each other. In other words, a particular equipment level check is not rechecked by an SMT. Also, SMTs are scheduled at the minimum frequency or period necessary to ensure reliability.

Since system testing is a form of maintenance, SMTs come under the Navy's planned maintenance system (PMS). Hence, SMT scheduling and format are identical to equipment-level maintenance actions. Each SMT is letter-number coded according to its required time interval. The letter D stands for daily check, W for weekly, M for monthly, and so forth.

For certain weapons systems, weekly tests are designed to check different equipment combinations, setups, and modes of operation. This concept requires that these weekly tests be scheduled over a 6-day period, Monday through Saturday. Quite often there will be 12 different weekly tests, identified W-1 through W-12. Depending on how a ship sets up its maintenance schedule, W-1 and W-7 would be held on Monday. On Tuesday, you run W-2 and W-8; Wednesday it's W-3 and W-9; and so forth. In this concept, each GMFCS and guide arm (on dual-arm launchers) is exercised daily with a different problem.

Testing Requirements

A typical missile system test program normally includes (but is not limited to) the items listed below:

- Daily system operability test (DSOT)
- Search radar readiness

- Supplemental (auxiliary) firing readiness
- Casualty mode operation
- Ship parameters (gyro inputs)
- Radar collimation/correlation
- ECCM capabilities
- Fire control radar parameters
- Live target tracking (AAW)
- Balloon tracking (designation accuracy)
- Surface target tracking

Overall system testing is centered around the daily system operability test (DSOT). (Actually, a DSOT is one of the 12 weekly scheduled checks, W-1 through W-12, mentioned earlier.) The DSOT is designed to exercise almost all of the functional circuits related to the primary mode of system operation. The DSOT is very important and we'll examine it in detail shortly.

Other system tests check the areas of the system not covered by DSOT. For example, weapons systems have different modes of operation. Antiair warfare (AAW) is the normal mode, usually. Antiship missile defense (ASMD), surface warfare (SUW), antisubmarine warfare (ASW), and shore modes are optional. There may also be a casualty mode to permit system operation should certain equipments be inoperable. Each mode is tested to ensure its continued reliability. The periodicities of these tests are usually greater, such as monthly, quarterly, or longer.

SMTs check the equipment in two major areas—alignment requirements and electrical operability requirements. Alignment requirements consist of in-space RF alignments and internal (shipboard) alignments. In-space RF alignments verify that RF beams from the search, fire control, and guidance radars all coincide. This is very important. Assume a search radar is tracking a target at 180° true bearing. Also assume a fire control radar beam is 10° out of alignment with the search radar. At designation, the fire control radar is searching empty space, 10° off target. Acquisition could be impossible.

Internal or shipboard alignments are mechanical and electrical in nature. They affect individual equipments and the interactions between different equipments. For example, consider a GMLS power drive system with its synchros and receiver-regulators. Synchronization will never be achieved with misalignments between the computer and the GMLS.

Alignment procedures are provided to correct any in-space RF or internal misalignments. However, they are only performed on an as-needed basis, when discovered by faulty test results.

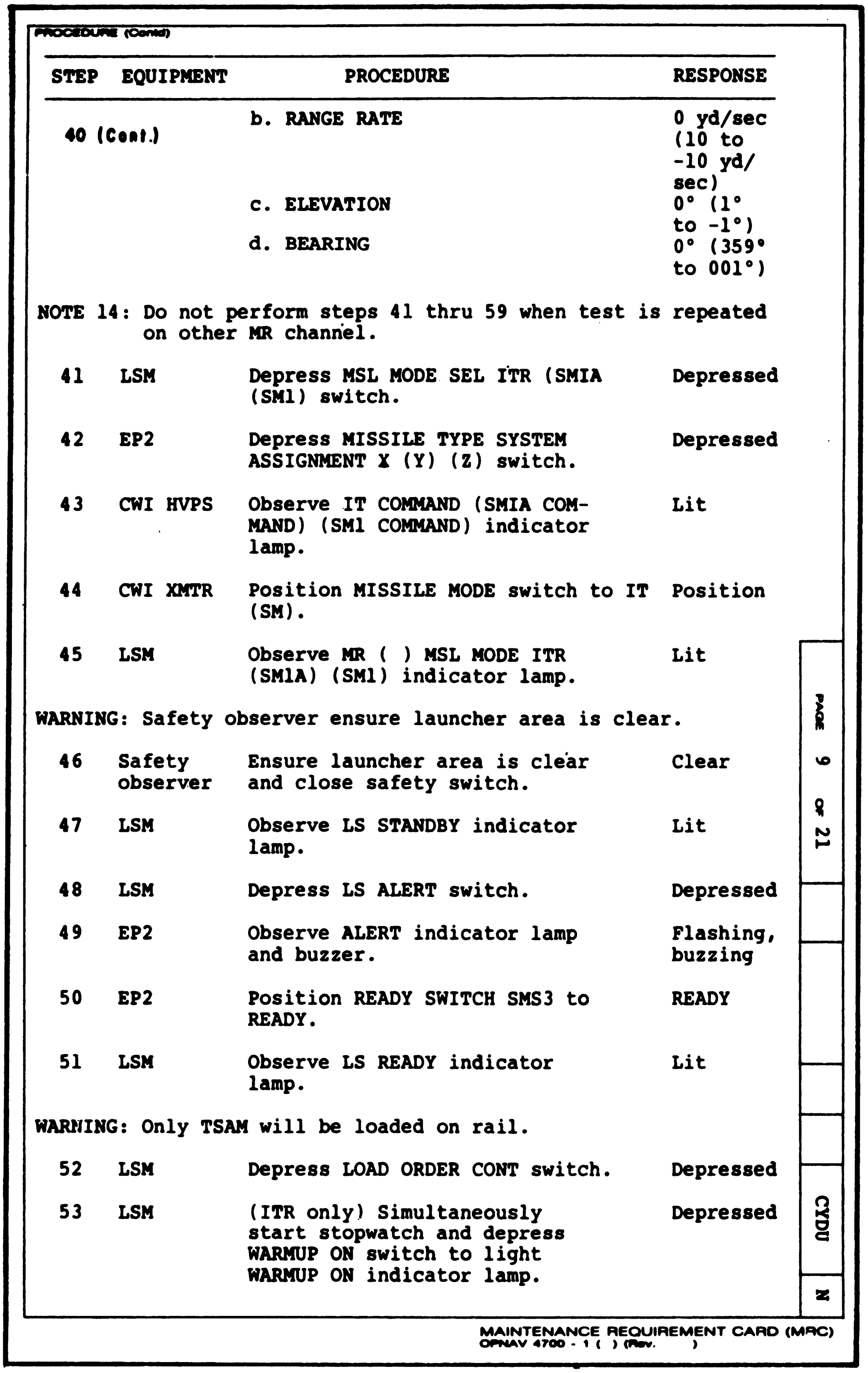
The quality of system test results can be determined by system responses and parameter tolerances. (Parameter—any set of values that determines the normal or desired characteristics and behavior of something.) Test result data may be obtained from indicators, lamps, dials, meters, and computer readouts (printouts). Analyzing the data provides the technicians with a "yardstick" for measuring the success or failure of a particular test.

Testing Procedures

System test procedures are printed on standard maintenance requirement cards (MRCs). Each system test MRC contains the same information as found on any other equipment MRC. Ships' 3-M Manual, volume I, OPNAVINST 4790.4, explains MRCs in detail.

The actual test procedure is presented in an easy-to-read, step-by-step format. Figure 9-16 shows a sample system test MRC page. Note that the information is listed in four columns:

1. Step—a number to indicate the phase or point in the test sequence.
2. Equipment—the equipment of a station/work center that performs the step.



PROCEDURE (Contd)

STEP	EQUIPMENT	PROCEDURE	RESPONSE
40 (Cont.)		b. RANGE RATE	0 yd/sec (10 to -10 yd/ sec)
		c. ELEVATION	0° (1° to -1°)
		d. BEARING	0° (359° to 001°)

NOTE 14: Do not perform steps 41 thru 59 when test is repeated on other MR channel.

STEP	EQUIPMENT	PROCEDURE	RESPONSE
41	LSM	Depress MSL MODE SEL ITR (SMIA (SM1) switch.	Depressed
42	EP2	Depress MISSILE TYPE SYSTEM ASSIGNMENT X (Y) (Z) switch.	Depressed
43	CWI HVPS	Observe IT COMMAND (SMIA COMMAND) (SM1 COMMAND) indicator lamp.	Lit
44	CWI XMTR	Position MISSILE MODE switch to IT (SM).	Position
45	LSM	Observe MR ( ) MSL MODE ITR (SM1A) (SM1) indicator lamp.	Lit

WARNING: Safety observer ensure launcher area is clear.

STEP	EQUIPMENT	PROCEDURE	RESPONSE
46	Safety observer	Ensure launcher area is clear and close safety switch.	Clear
47	LSM	Observe LS STANDBY indicator lamp.	Lit
48	LSM	Depress LS ALERT switch.	Depressed
49	EP2	Observe ALERT indicator lamp and buzzer.	Flashing, buzzing
50	EP2	Position READY SWITCH SMS3 to READY.	READY
51	LSM	Observe LS READY indicator lamp.	Lit

WARNING: Only TSAM will be loaded on rail.

STEP	EQUIPMENT	PROCEDURE	RESPONSE
52	LSM	Depress LOAD ORDER CONT switch.	Depressed
53	LSM	(ITR only) Simultaneously start stopwatch and depress WARMUP ON switch to light WARMUP ON indicator lamp.	Depressed

PAGE 9 OF 21

CYDU

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MAINTENANCE REQUIREMENT CARD (MRC)
OPNAV 4700 - 1 ( ) (Rev.)

167.874

Figure 9-16.—Sample system test MRC page.

3. Procedure—what action must be accomplished.
4. Response—the "desired" response or result from a particular step.

Also note that pertinent safety warnings and operational notes (special instructions) precede important steps.

Since a system test normally requires the participation of many individual stations/work centers, coordination is a must. DSOT, for example, can include four or five different tations. Each station will have its own copy of the test's MRC. That way, all involved personnel can follow along with each step as it occurs.

Test procedures are arranged so one individual serves as the test conductor/coordinator. The test conductor controls and directs the test's performance (keeps it going). Normally, this individual is located at the WDE, but that varies among ships. The test conductor can also call out each step number and record any response data.

Refer to figure 9-16, step 49. The test conductor calls out "Step 49." You, the EP2 panel operator, must observe the reaction of the GMLS's ALERT indicator lamp and buzzer. Knowing how your system operates, you realize the lamp should flash and the buzzer buzz when they are activated. (Step 48 activates them.) If they work properly, you report over the sound-powered phone circuit, "Step 49, flashing and buzzing." The test conductor acknowledges your verbal response and the test goes on. This procedure may vary from ship to ship, but the idea is the same.

Test Evaluation and Fault Isolation

Each system test is divided into independent phases where possible. This helps in conducting the test and is a fault isolation aid. Particular parts of the system may be checked without conducting an entire test.

Selected parameters under test are sampled or measured to specified tolerances. These tolerances, along with the desired responses, are listed on the MRC following the applicable steps. Step 40 on figure 9-16 shows parameters and tolerances.

Fault isolation directories are located in each MRC and keyed to corresponding test steps (figure 9-17). If an out-of-tolerance condition or incorrect response is observed, the fault isolation direction should be consulted. It lists system and equipment OPs that can be referenced to aid in troubleshooting.

Ideally, the test should be completed without pause for fault isolation. Completing the test permits a more accurate evaluation of the fault. It also results in the most efficient use of manpower.

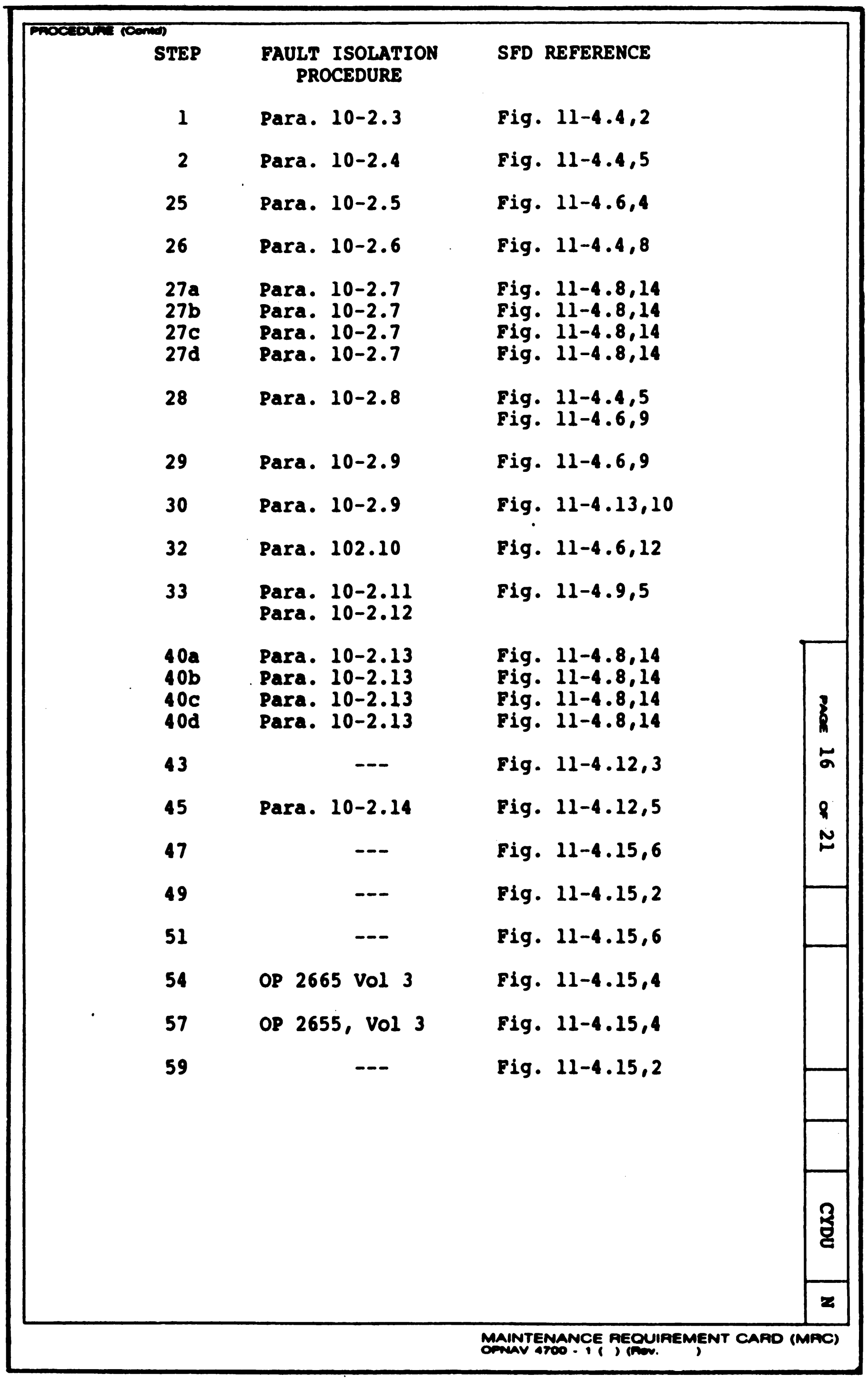
A significant feature of a GMFCS is its general purpose digital computer. In addition to solving the tactical fire control problem, the computer is also a test instrument. Digital test programs have been designed to enhance system testing.

Dynamic digital tests are controlled by the GMFCS's computer complex or the NTDS/WDS's complex. The computer stores special test programs and generates a variety of dynamic target problems. The test program solves the fire control problem to arrive at ideal values. These values are then compared with actual test responses to provide error monitoring. Teletypewriters can be used to print out this information for evaluation.

A new concept in digital system testing uses the computer to isolate a fault. This can be performed during or separate from normal computer operations. The advantages are obvious—quicker repair times and increased readiness.

DAILY SYSTEM OPERABILITY TEST

The purpose of DSOT is to assess missile system readiness in its normal mode of operation. For most systems, this would be the AAW mode, although the specific functions tested may vary



PROCEDURE (Contd)

STEP	FAULT ISOLATION PROCEDURE	SFD REFERENCE
1	Para. 10-2.3	Fig. 11-4.4,2
2	Para. 10-2.4	Fig. 11-4.4,5
25	Para. 10-2.5	Fig. 11-4.6,4
26	Para. 10-2.6	Fig. 11-4.4,8
27a	Para. 10-2.7	Fig. 11-4.8,14
27b	Para. 10-2.7	Fig. 11-4.8,14
27c	Para. 10-2.7	Fig. 11-4.8,14
27d	Para. 10-2.7	Fig. 11-4.8,14
28	Para. 10-2.8	Fig. 11-4.4,5 Fig. 11-4.6,9
29	Para. 10-2.9	Fig. 11-4.6,9
30	Para. 10-2.9	Fig. 11-4.13,10
32	Para. 102.10	Fig. 11-4.6,12
33	Para. 10-2.11 Para. 10-2.12	Fig. 11-4.9,5
40a	Para. 10-2.13	Fig. 11-4.8,14
40b	Para. 10-2.13	Fig. 11-4.8,14
40c	Para. 10-2.13	Fig. 11-4.8,14
40d	Para. 10-2.13	Fig. 11-4.8,14
43	---	Fig. 11-4.12,3
45	Para. 10-2.14	Fig. 11-4.12,5
47	---	Fig. 11-4.15,6
49	---	Fig. 11-4.15,2
51	---	Fig. 11-4.15,6
54	OP 2665 Vol 3	Fig. 11-4.15,4
57	OP 2655, Vol 3	Fig. 11-4.15,4
59	---	Fig. 11-4.15,2

PAGE 16 OF 21

CYDU

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MAINTENANCE REQUIREMENT CARD (MRC)
OPNAV 4700 - 1 ( ) (Rev.)

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Figure 9-17.—Sample test fault directory.

between systems. DSOT usually involves testing target detection and/or designation, acquisition, tracking, and missile firing. A typical DSOT is described in the following paragraphs. Figure 9-18 is a simplified block diagram of DSOT data flow.

Preliminary Setup

Before starting the test sequence, each equipment station prepares for operation. Technicians follow a list of instructions provided at the beginning of the MRC test procedure. Most setups involve equipment turn-on actions and switch positioning. In some cases, the test conductor announces a particular equipment configuration.

Detection

In systems that test this function, a synthetic (artificial or man-made) target video is inserted in the 3-D search radar. The target is at a predetermined range, bearing, and elevation. These data are routed through normal distribution circuits. The target video is checked at the NTDS/WDS or WDS consoles. The test target is then entered into a WDS tracking circuit.

GMFCS Assignment

If the detection function is not tested, the NTDS/WDS or WDS operator initiates the test target at the TSTC. A GMFCS is assigned to one of the tracking channels. The accuracy of the designated position is checked at the radar set console. Position repeat back data are checked at the NTDS/WDS or WDS consoles.

Acquisition and Static Track

A test RF generator provides the fire control radar with a simulated target return signal. Radar jamming signals may also be provided. The radar's scope display is monitored to see how well the radar can acquire the target. How much of the radar receiver is tested is determined by where the test signal is introduced. The test signal contains information needed for radar tracking, including angle error and range. Target parameters are usually controlled by a test program, as previously mentioned. Control is also possible from an analog test set.

Launcher Loading and Missile Selection

After track is attained, the launcher goes through a loading sequence to place a training

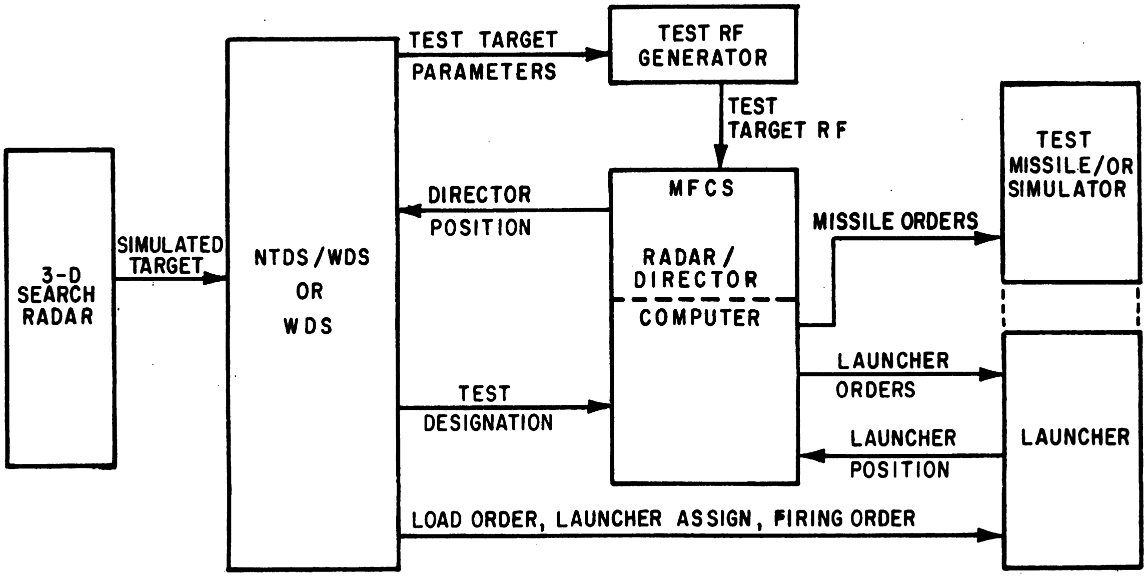

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Figure 9-18.—Simplified DSOT data flow.

missile on the rail. SAFETY REMINDER: VERIFY THAT ONLY A TEST MISSILE HAS BEEN LOADED. Otherwise, the DSOT would result in the actual launching of a live missile. (Don't laugh, it HAS happened!)

Missile type and mode selection might also be tested at this time. The test missile's simulator provides these functions.

Dynamic Evaluation

During this phase of DSOT, two aspects of system operation are tested. The first is the FCS tracking of a dynamic target. The second is launcher assignment and synchronization to a computer-ordered position.

Target parameters are selected that simulate an incoming enemy aircraft. The fire control system is monitored to ensure smooth and accurate tracking. The launcher is assigned and the fire control problem solution verified by monitoring launcher and missile orders.

Engageability displays are observed at the weapons control area. Displays indicate when the target is within firing range and the launcher is in a clear firing bearing. If all conditions are correct, the firing circuit is closed (ITL). A proper firing indication is monitored at the launcher station and is verified at various weapons stations.

The launcher operator must initiate a missile-in-flight condition. That is usually done by depressing a switch button which simulates the launcher rail is clear/empty. In effect, we electrically "lie" to the system, but it is necessary to continue the test.

Test Missile Readouts

Certain signals are essential to missile operation, but may not be automatically checked. Visual observations, by means of built-in lamps and dials, are made at the test missile's simulator. Signals, such as missile orders, are sometimes checked with a multimeter. A serious safety hazard exists when you are making measurements or otherwise approaching the missile while it is on the launcher. ALWAYS ENSURE THAT ALL LAUNCHER MOTORS ARE STOPPED BEFORE APPROACHING THE MISSILE.

After missile readouts are finished, all stations secure or set up for the next test.

OCSOT

Another test you may be involved with is the overall combat system operability test (OCSOT). The OCSOT provides a tool to make rapid assessments of ship readiness. It tests the entire combat system as an integrated system. An OCSOT uses normal equipment, software, and interfaces during both simulated and controlled live target phases. As a rule, the following systems are tested:

- Guided missile fire control
- Gun fire control
- Antisubmarine warfare
- Electronic warfare
- Tactical data
- Identification friend or foe (IFF)
- Search radars
- Electronic navigation

The OCSOT has specified parameters such as range, bearing, and elevation tolerances for all phases. Proper reaction times for systems and operators are also monitored. As an added benefit, the OCSOT results in training for improvement of operational readiness in a combat environment.

TRAINING MISSILES

A training missile is an integral part of every missile weapons system. A training missile consists of two major subassemblies—a training round and a guided missile simulator. The training round is an inert shape or body that resembles a tactical missile shape. The guided missile simulator is an electronic unit or module that simulates the electrical performance of a tactical missile.

In the SMS community, the two primary training missiles are:

1. Training surface-to-air missile (TSAM)—used by the Terrier Mk 10 GMLSs.

2. Guided missile training round (GMTR) (pronounced gim-ter)—used by the Tartar Mk 11, 13, 22, and 26 GMLSs.

Other training rounds and missiles do exist. Examples include the ASROC training round and the (relatively new) training antisubmarine warfare missile (TASWM). Although these items are special-purpose equipments, functionally they are similar to TSAMs and GMTRs. The text will limit its discussion to TSAMs and GMTRs.

GENERAL PURPOSES

Training missiles are electrically and mechanically compatible to their launching and fire control systems. Training missiles are also capable of simulating the performance of any tactical missile handled by a particular weapons system.

TSAMs and GMTRs are carried by combatant ships for two purposes—training and testing. They are used to train personnel in magazine loading, launcher operation, missile firing, and missile handling evolutions. TSAMs and GMTRs are also used during DSOT and as an aid in other system testing/equipment maintenance actions. The training and testing functions are really inseparable operations and greatly contribute to overall system readiness.

Training missiles may also be used as display shapes. As your ship enters/leaves port, the TSAMs or GMTRs will be loaded to the launcher. The same thing applies for public/VIP tour demonstrations. This policy may vary among commands, but it is the general rule.

TSAMs and GMTRs are mandatory items in a magazine loadout. Single-arm GMLSs will carry one training missile; dual-arm launchers will carry two training missiles. Although these missiles are inert rounds (contain no explosive materials), they should always be treated as real tactical weapons.

TERRIER TSAM

The current version of the Terrier TSAM is designated the Mk 45 Mod 0. The complete round (figure 9-19) consists of a trainer missile, trainer booster, and a guided missile simulator. The external sections and markings are similar to the Terrier BT-3 missile. However, the entire round adequately simulates Standard (ER) missile configurations for handling (training) purposes.

Individual sections of the TSAM are ballasted dummies. The guided missile simulator mounts in a special compartment of the trainer booster. (Refer to figure 9-20.) For visual identification purposes, the TSAM is painted blue. Tail control surfaces, dorsal fins, and booster fins are painted white.

All electrical connections from the launcher to the TSAM are made in the same manner as to a tactical round. Figure 9-20 shows the location of the booster firing contacts, booster-to-launcher contactor pad, and the identification/warmup contactor.

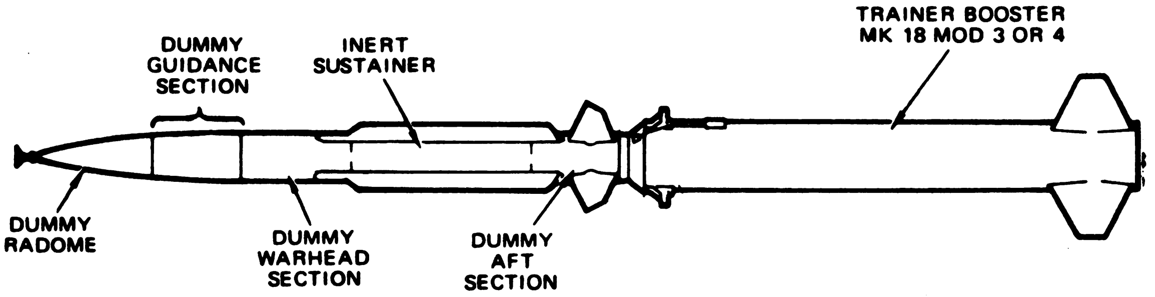

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Figure 9-19.—Mk 45 Mod 0 TSAM for Terrier systems.

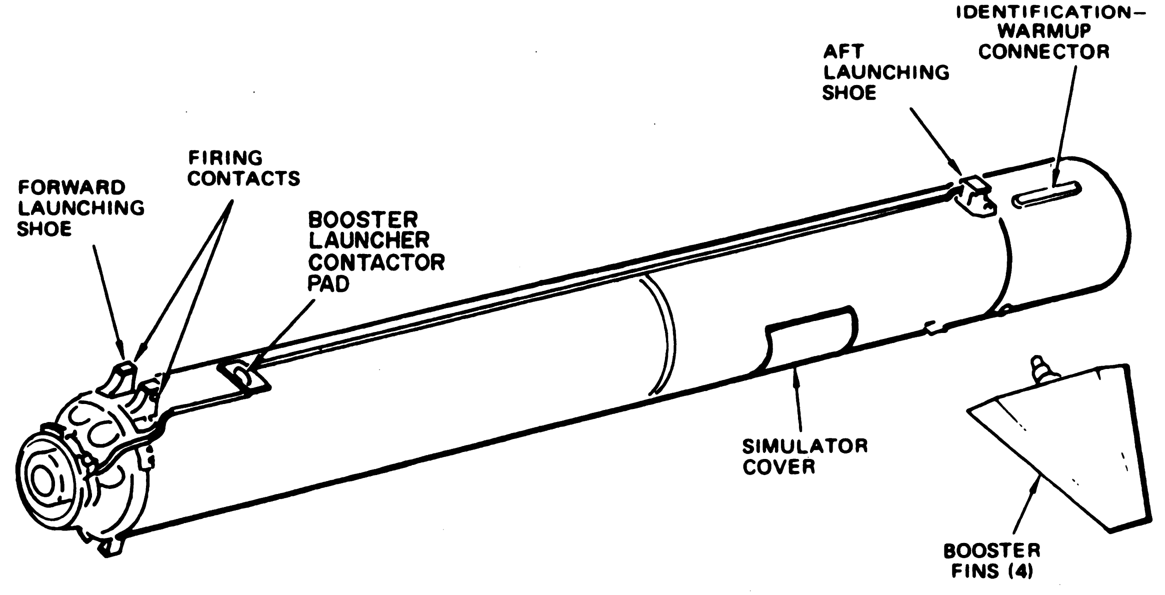

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Figure 9-20.—TSAM booster.

Terrier TSAMs are capable of carrying two types of guided missile simulators. The older type of simulator is designated SM-159D/DSM. It simulates HT/HTR, BT, and SM-1 (ER) missile loads and responses. The newer type of simulator is designated the Mk 74 Mod 0 (figure 9-21). This simulator has upgraded capabilities to replace the SM-159D/DSM simulators on ships with SM-2 weapons systems. The Mk 74 simulator simulates the loads and responses of BT, SM-1 (ER), and SM-2 (ER) missiles.

Both simulators serve as test units to check the operation of the GMLS and the FCS. They are secured in the booster's simulator compartment by mounting assemblies. The front panels of the units are accessible after a Plexiglas protective cover has been removed.

Terrier missile system testing may be performed either with the TSAM loaded on the launcher or with the TSAM remaining inside the missile house. This last feature, in-house testing, is unique to the Terrier systems. It eliminates problems involving inclement weather and personnel hazards around a moving launcher. Additionally, in-house testing reduces the wear and tear on the TSAM's launching shoes. This shoe wear is particularly acute on horizontal loading systems (like Terrier) and presents a serious safety hazard.

To conduct in-house tests, the simulator is first removed from the TSAM. It is then mounted behind the simulation selector panel atop the GMLS's EP2 panel. (Refer to figure 2-21.) The simulator and selector panel are connected into the GMLS control system. Testing requirements (such as DSOT) can now be checked without loading the launcher.

In-house testing cannot fulfill all system testing functions. On-rail launcher continuity, plus power drive response to dynamic orders (remote), must be checked periodically. Outside testing requires that the TSAM, with simulator installed, be loaded on the launcher.

The simulator is powered from the FCS through GMLS circuits/components. Control and status signals are supplied to the TSAM's simulator. Here they are interfaced with level detector circuits and the firing interlock circuit. The firing interlock circuit is the main circuit of the simulator. It determines whether the transmitted signals are at required values and in proper sequence. If all levels are correct, the simulator generates the MISSILE READY signal. This represents the launching of a missile.

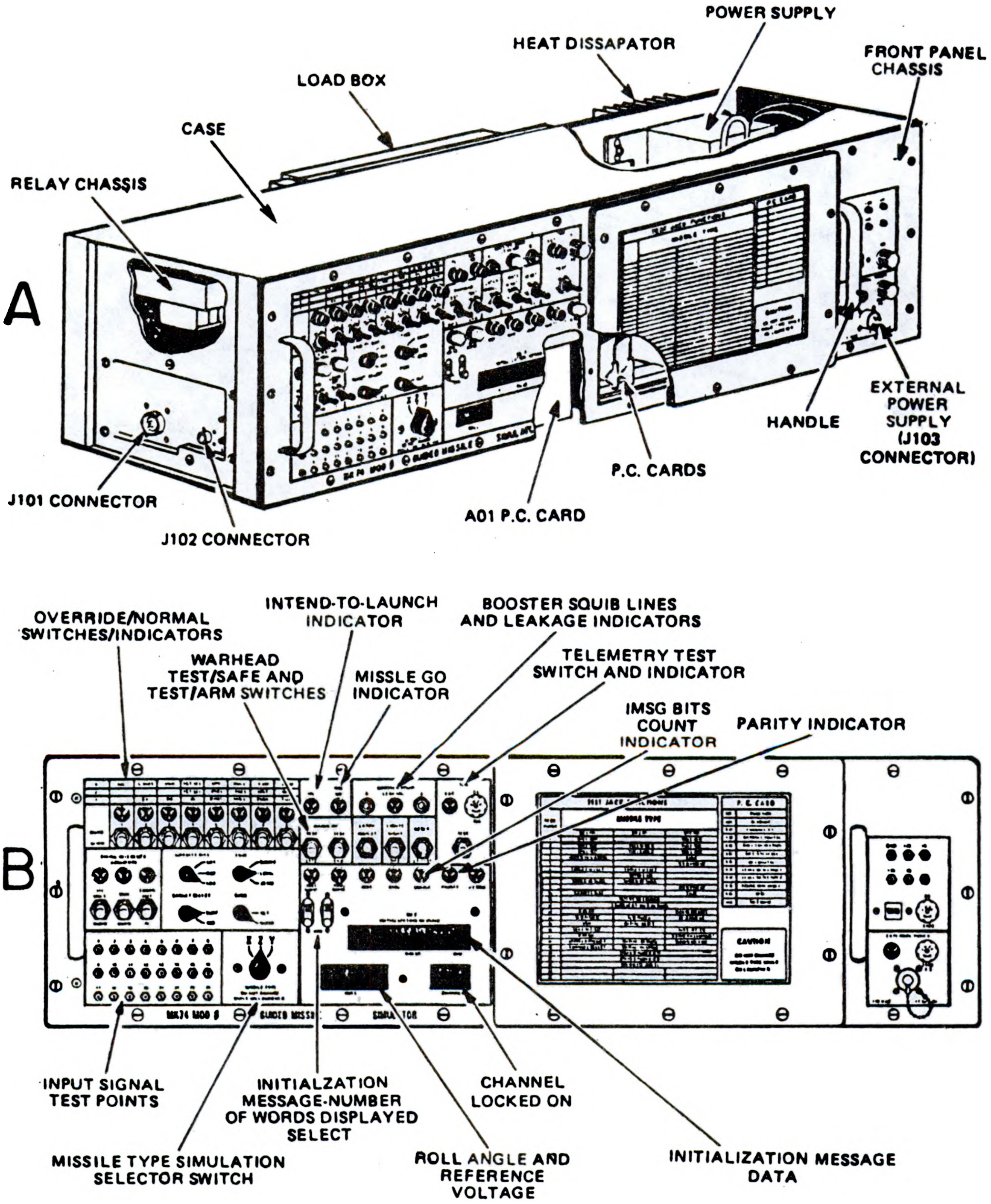
POWER SUPPLY
HEAT DISSAPATOR
FRONT PANEL CHASSIS
LOAD BOX
CASE
RELAY CHASSIS
A
J101 CONNECTOR
J102 CONNECTOR
A01 P.C. CARD
P.C. CARDS
HANDLE
EXTERNAL POWER SUPPLY (J103 CONNECTOR)
OVERRIDE/NORMAL SWITCHES/INDICATORS
INTEND-TO-LAUNCH INDICATOR
BOOSTER SQUIB LINES AND LEAKAGE INDICATORS
WARHEAD TEST/SAFE AND TEST/ARM SWITCHES
MISSLE GO INDICATOR
TELEMETRY TEST SWITCH AND INDICATOR
IMSG BITS COUNT INDICATOR
PARITY INDICATOR
B
INPUT SIGNAL TEST POINTS
INITIALZATION MESSAGE-NUMBER OF WORDS DISPLAYED SELECT
CHANNEL LOCKED ON
MISSILE TYPE SIMULATION SELECTOR SWITCH
ROLL ANGLE AND REFERENCE VOLTAGE
INITIALIZATION MESSAGE DATA

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Figure 9-21.—View A—the Mk 74 Mod 0 guided missile simulator; View B—front panel.

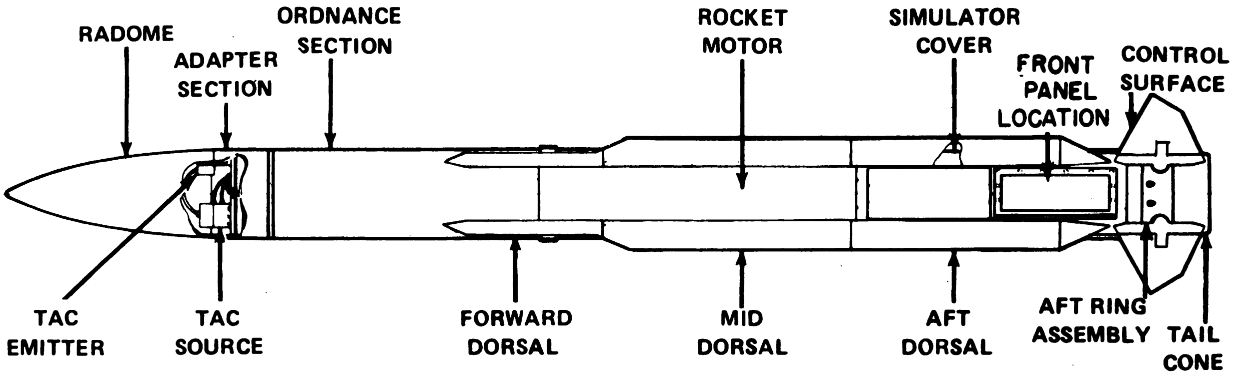

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Figure 9-22.—Mk 60 Mod 4 GMTR for Tartar systems.

NOTE: As this text was written, a third simulator was being introduced to the Terrier community. It is designated the Mk 89 Mod 0 simulator and has further upgraded capabilities. It is designed to be compatible with the latest SM-2 (ER) Terrier weapons system configurations. Eventually, the Mk 89 simulator will replace all the older units.

TARTAR GMTR

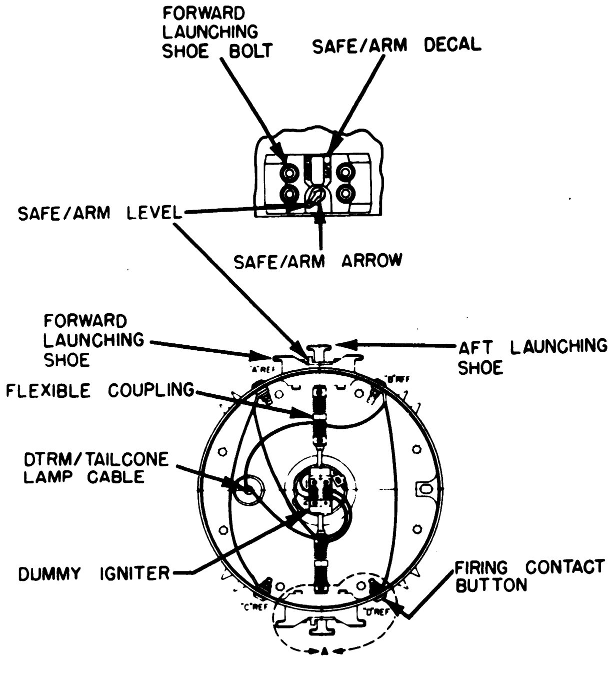
The current version of the Tartar GMTR is designated the Mk 60 Mod 4. It is capable of simulating ITR, SM-1A (MR), SM-1 (MR), SM-2 (MR), Standard ARM, and Harpoon missiles. Externally, the GMTR is similar to a tactical SSSM round. Although the sections and markings are not the same, the GMTR adequately serves for all general handling and display purposes.

The Mk 60 Mod 4 GMTR is made up of two major subassemblies:

1. Mk 59 Mod 0 or 1 guided missile dummy round (GMDR)
2. Mk 63 Mod 4 guided missile simulator (GMS)

The GMDR (figure 9-22) forms the body of the GMTR. It consists of ballasted dummy sections and is painted blue. Tail control surfaces and dorsal fins are painted white. The Mk 63 Mod 4 GMS is located in a compartment of the dummy rocket motor section. A removable door protects the simulator from the outside elements. The door has a clear plastic window to permit visual observation of switch positions and lamp displays.

A target acquisition console (TAC) source and emitter are mounted in the adapter section of the GMDR. These units are used in testing Standard ARM missile features. The dummy rocket motor igniter assembly is mounted in the forward part of the dummy DTRM (figure 9-23). Four firing



83.507

Figure 9-23.—GMTR dummy igniter and S&A lever.

contact buttons and the S&A (SAFE/ARM) levers are also located here.

The tail cone assembly of the GMDR includes two external electrical connectors (figure 9-24). The 6-pin missile-to-magazine connector provides for round identification and application of warmup power (if applicable). The missile-to-launcher connector (MLC) provides a 23-pin jack receptacle for application of preflight missile orders and simulator power. The MLC is easily removed/replaced and protected by a rubber composition pad.

The tail cone assembly houses a large red light bulb called the tail cone lamp. When a firing circuit is completed, the lamp lights to simulate rocket motor ignition. The aft end of the tail cone is sealed with a clear plastic window. The tail cone lamp is easily observed through this window. Figure 9-24 also illustrates how a GMS is installed and connected (electrical cables) to the GMDR.

The Mk 63 Mod 4 GMS is a very versatile electronic unit. Figure 9-25 shows the simulator's front panel. The GMS furnishes the electrical loads, voltages, frequencies, and responses for any of the six missile types mentioned earlier. A round identification switch (item 1 in the figure) selects the correct circuits for simulation of the desired missile type. Lamps, switches, displays, and test jacks on the front panel facilitate DSOT and other system testing.

Most of the major simulator circuits are designed to function independently. They also have associated indicators to display readouts of their operations. The roll corrector circuit includes

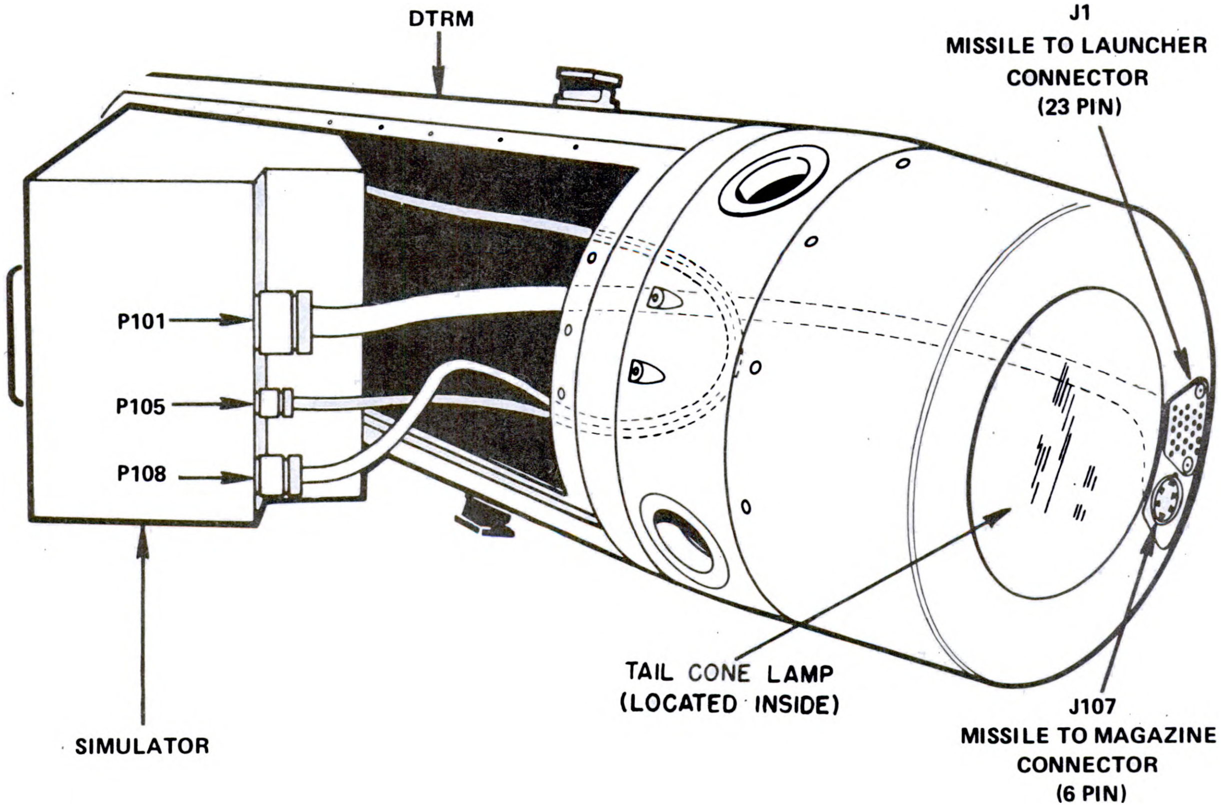


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Figure 9-24.—Tail cone assembly components and simulator removal.

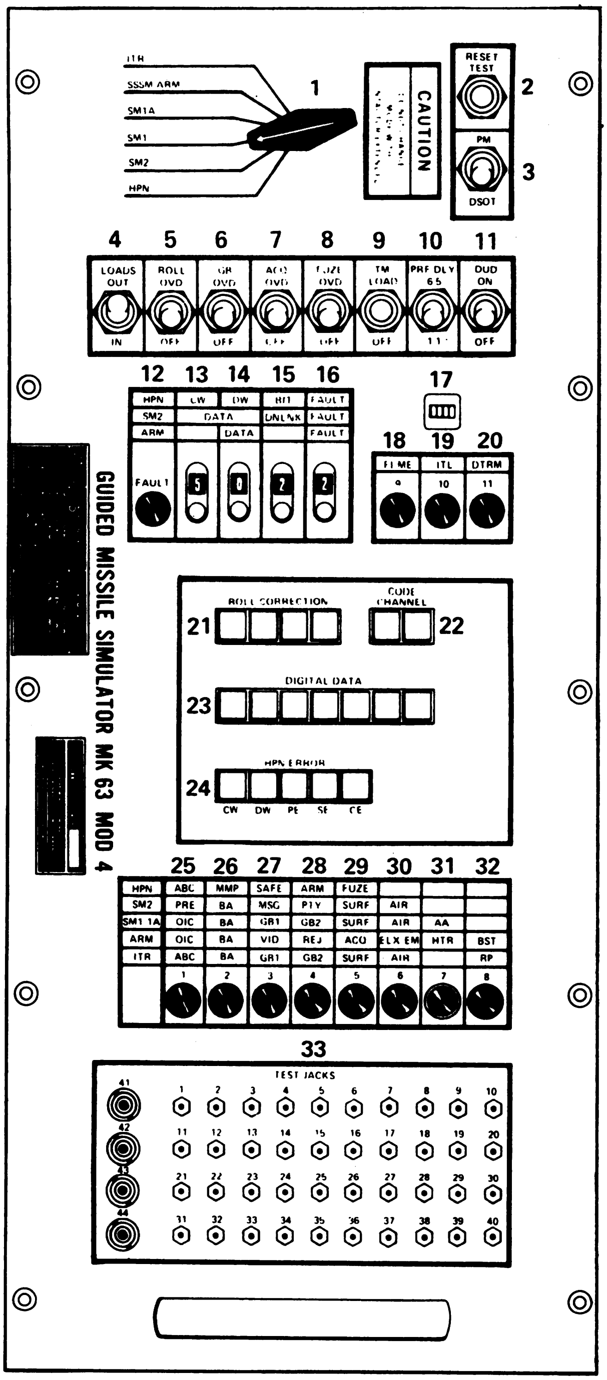

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Figure 9-25.—Mk 63 Mod 4 guided missile simulator's front panel.

an LED display (item 21 in the figure) for direct reading in degrees of roll. Visual readout of the selected missile code or channel number (item 22 in the figure) is also displayed on an LED readout.

NOTE: Depending on weapons system capability, certain ships still retain the older types of Tartar training missiles. These rounds are identified as the Mk 60 Mod 0, 1, or 3 GMTR and the Mk 16 Mod 2, 3, or 4 TSAM. As these ships undergo update modifications, they will receive the latest GMTR configuration. As this text was written, a Mk 60 Mod 6 GMTR was being developed.

TRAINING MISSILE MAINTENANCE

The importance of maintaining all training missiles in peak condition cannot be stressed enough. If these devices are allowed to deteriorate, the operational readiness of the entire weapons system is in jeopardy. Gunner's Mates are responsible for the proper maintenance and care of the TSAMs and GMTRs. A majority of these maintenance actions come under the headings of inspecting and servicing.

Maintenance requirement cards (MRCs) provide the guidance necessary to maintain the training missiles. The MRCs describe the required periodic and unscheduled maintenance actions applicable to the round. In case of functional problems or equipment failure, be sure to consult these MRCs.

Inspections

Inspections include the preventive maintenance procedures required to detect problem areas before they cause equipment failures. Listed below are a few examples of what to look for during a training missile inspection.

1. Examine all painted surfaces for chipping and scratches.

2. Inspect tail control surfaces for hard or rough movement as they are folded/unfolded.

3. Inspect the S&A levers/arming tool socket. Ensure they are in the SAFE position and they offer some tension or resistance to being turned. Also inspect the firing contact buttons or points for wear and cleanliness.

4. Examine all plastic covers/windows for cracks and chips.

5. Examine the simulator's front panel items; check for damaged lamp lenses, broken or loose switches, and so forth.

6. Inspect the launching shoes for excessive or uneven wear by using a micrometer or special GO/NO-GO gage tool. Consult the applicable training missile OP or MRC for maximum/minimum wear tolerances.

If possible, correct any deficiencies noted at the time of inspection. If an immediate repair cannot be made, report the problem to proper authority.

Servicing

Servicing a training missile prevents corrosion and deterioration of the round. While in stowage, training missiles require no external care other than routine cleaning. Gross accumulations of oil, grease, and dirt must not be permitted to remain on the round's surface. If cleaning is required, use a clean soft rag moistened with an approved dry-cleaning solvent. Do not pour the solvent onto the round; rather, use a dampened cloth. Wipe the round dry afterwards. Use a mild soap-and-water solution on a damp cloth to clean transparent covers. Do not use dry-cleaning solvent on these covers as the solvent tends to attack the plastic.

Corrosion is a training missile's worst enemy. All bare metal (magnesium, aluminum, and steel) parts of a round are affected quickly by excessive levels of moisture. This emphasizes the point of inspecting painted surfaces for chips and scratches. Salt spray is especially damaging. If the round is exposed to salt spray, wash it with fresh water before returning it to the magazine.

After the training missile has been cleaned/washed; wipe it down with an approved corrosion-preventive compound. This compound may come in a concentrated liquid form or in a spray can. (The concentrated liquid must be mixed/diluted with water; follow the directions on the can.) Be sure to wipe all areas of the training missile. Pay particular attention to tail and fin mounting sockets. If corrosion is noticed inside these sockets, apply the compound liberally to the socket area. Then carefully clean the socket with an LP air supply. Reapply the compound, but do not wipe it dry. This point applies to any application of corrosion-preventive compound. If you wipe it dry, you wipe away the compound's effectiveness.

Training missiles are NOT sealed, watertight devices. Excessive exposure to moisture not only affects the round's external surfaces but can cause serious internal damage. This problem is particularly acute in the area of the simulator. Remember, a simulator is a very sensitive electronic test instrument.

Training missiles will corrode—that's a fact of life. Therefore, an effective maintenance program is mandatory. Also, DO NOT LET THE TSAM/GMTR GET WET. If it begins to rain, immediately unload the round to the magazine. If this means interrupting a DSOT, so be it. The DSOT can be set up and rerun in a matter of minutes after the storm passes. It may take you days to thoroughly dry out a "soaked" training missile and its simulator. In the long run, it is better to keep the round dry.

REFERENCE SOURCES

The following publications were used as reference sources to develop the material in this chapter.

1. NAVEDTRA 10199-C, *Gunner's Mate M 3 & 2*

2. NAVEDTRA 10207-B, *Fire Control Technician G 3 & 2*

3. NAVEDTRA 10224, *Fire Control Technician M 3*

4. NAVSEA OP 4093, *Terrier BT and HTR, Standard Missiles, and Training Rounds*

5. NAVSEA OP 4094, *Tartar, Standard (MR), ISSMC, and Harpoon Guided Missiles, Shapes and Simulators*

6. NAVSEA OP 4575, *Guided Missile Training Round Mark 60 Mod 4*

CHAPTER 10

GENERAL MAINTENANCE

The purpose of this chapter is to introduce you to the subject of maintenance. We will also explain various techniques and procedures that apply to general ordnance equipment. Specific information for your equipment can be found in several sources, one of which is a GMLS OP. Equipment and system maintenance requirement cards (MRCs) are other valuable references.

The effectiveness and reliability of the equipment depend largely on the care and attention YOU give it. A faulty GMLS puts the entire weapons system out of commission. One open lead in a launcher-to-missile contactor destroys the purpose of the guided missile. Improperly lubricated equipment may freeze up. A clogged filter can damage a hydraulic power drive. You can probably think of many more instances where improper maintenance can reduce equipment readiness.

As a GMM, your maintenance activities are extremely important in contributing to the operational readiness of the system. All too often, the small routine tasks are taken for granted. There isn't much glory in pumping a grease gun or tightening terminal board screws. Routine maintenance tasks such as these may not be exciting. However, they must be done to the best of your abilities.

MAINTENANCE DEFINED

The work you do on the equipment falls into two broad categories. First, there are actions you take to reduce or eliminate failures. These actions tend to prolong the useful service life of the equipment. The second category involves the actions you take when a part fails and the equipment is out of service. Your job, then, is to make repairs and restore the gear to operable condition. Therefore, we can divide maintenance into two categories—(1) preventive and (2) corrective. Figure 10-1 shows the different phases of each category.

PREVENTIVE MAINTENANCE

Let's use a familiar experience to illustrate the meaning of preventive maintenance. You have probably owned a car and know what must be done to keep it in good shape. The oil and water levels must be inspected periodically. Filters must be changed. The wheels must be balanced and the front end aligned. Brake wear must be checked. Spark plugs must be cleaned and gapped properly. The carburetor must be adjusted and the engine's timing set.

Obviously, there is more to having a car than simply driving it. If the manufacturer's suggested maintenance program is followed, the car should provide many years of reliable service. The purpose of the car's maintenance program is to stop trouble before it starts. The purpose of a GMLS's maintenance program is identical.

Preventive maintenance consists of the normal care and upkeep necessary to keep the equipment in peak operating condition. These actions also reduce the chance of sudden equipment failure. Figure 10-1 shows the major types of activities involved in preventive maintenance. They are periodic inspections, cleaning, lubrication, and performance checks. Minor alignments and adjustments can also be included in preventive maintenance work.

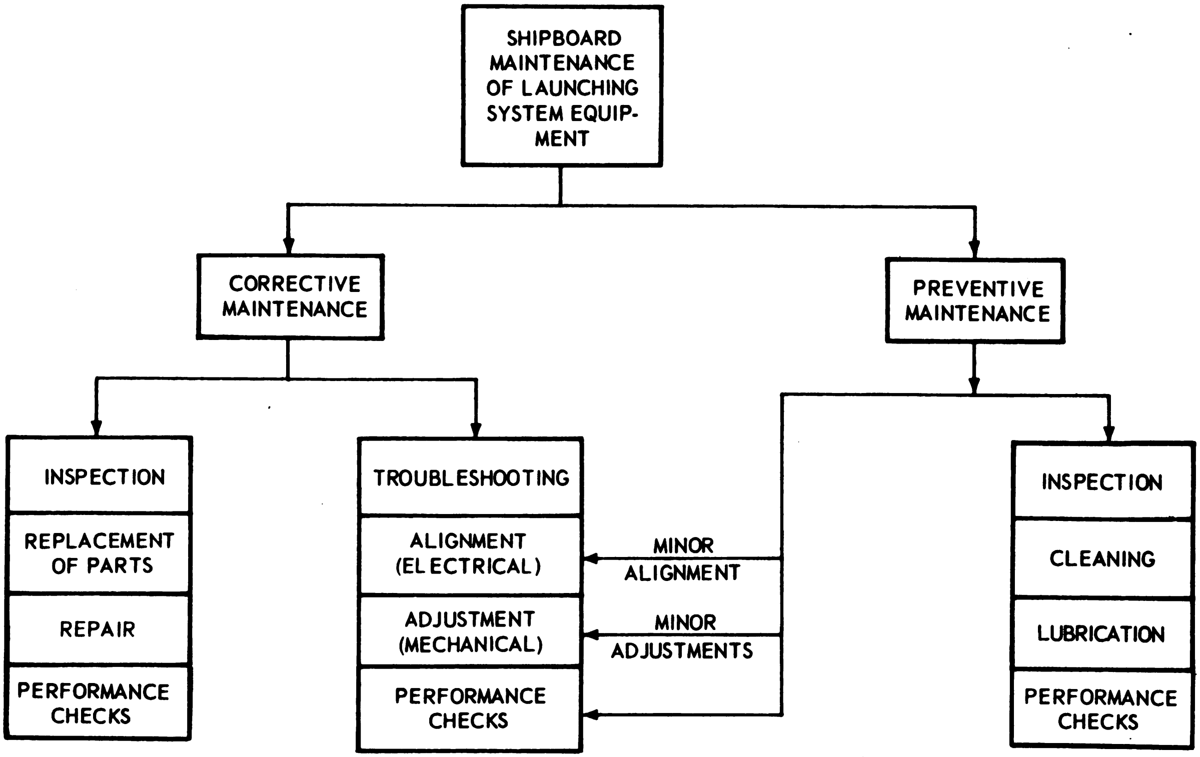

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Figure 10-1.—Phases of maintenance.

CORRECTIVE MAINTENANCE

Corrective maintenance includes the work done to restore the equipment to operational status. The major types of activities involved in corrective maintenance are shown in figure 10-1. Normally, these actions are associated with an equipment breakdown or damage. A failed part must be replaced or repaired to fix a problem. However, corrective maintenance also should be associated with preventive maintenance. If a preventive inspection or performance check reveals a potential problem or out of tolerance condition, take corrective action immediately.

Preventive and corrective maintenance activities often overlap and it is difficult to separate the two. It is not absolutely essential to sharply define each job performed, either. The main point can be summarized with the old saying, "An ounce of prevention is worth a pound of cure." If you must put a priority on one type of maintenance, preventive maintenance should come first.

MAINTENANCE LEVELS

Maintenance work on ordnance equipment is accomplished on three distinct levels. First, there is the work done aboard ship at the work center and divisional levels. This work is called organizational maintenance. It represents the preventive and corrective actions performed by the ship's force on a daily basis.

However, the ship's force does not always have the facilities or skills to do certain less frequent, but necessary, jobs. Examples include rewinding an electric motor, rebuilding and testing a large valve, and so forth. Work of this nature is usually done aboard tenders and other repair ships. It can also be accomplished by or at the local mobile technical units (MOTUs) and shore intermediate maintenance activities (SIMAs).

These fleet support units have the facilities, personnel, and skills necessary to do such jobs. This level of maintenance work is called intermediate maintenance.

Finally, there are some jobs that are customarily accomplished in a naval shipyard. These jobs are very complex and/or time consuming. Examples include major equipment overhauls, lifting a launcher to inspect its training circle, and the like. Such work may be done by the shipyard workers and/or ship's force. This level of maintenance work is called depot maintenance.

You will find that preventive and corrective maintenance takes place throughout all organizational, intermediate, and depot levels of maintenance. Your immediate concern is with the tasks performed at the shipboard organizational level.

ORDNANCE DRAWINGS

To do any kind of maintenance work, you must be familiar with the equipment. A good way to learn about the gear is to study its hardware. But you will learn faster, and you will learn more by also using certain reference sources. This manual is such a source; so are the OPs, ODs, and other publications. In many ways, however, your most valuable reference source could be an ordnance drawing.

Manufacturers of ordnance equipment make drawings of their "products." Copies of these drawings are reproduced by blueprinting, photocopying, or in some other way. They are supplied to every ship or installation that has the equipment or, for some other reason, requires copies of the drawings. Many of the drawings are reproduced in OPs and other technical manuals furnished by NAVSEA or the contractor who manufactures the equipment.

TYPES OF DRAWINGS

Drawings differ depending on their purposes. The main types of drawings, classified according to purpose, are described below.

General arrangement drawings—These drawings show the complete equipment in an assembled condition. The general appearance and relationship of important assemblies and subassemblies is illustrated. General arrangement drawings also identify other drawings that describe the components of the equipment.

Installation drawings—These show such features as mounting pads and brackets, shock mounts, points for entrance of cabling and mating mechanical parts, and type of wiring required. Dimensions of mounting hardware needed and directions for how to orient the equipment and secure it in place on a bulkhead or deck are included. One variety of this type of drawing is called an outline drawing. It shows the overall dimensions and clearances required for operating and servicing the installed equipment.

Assembly and subassembly drawings—These drawings show the construction details of the assemblies which make up the complete equipment. In general, you can think of an assembly (or subassembly) as any group of two or more parts assembled to make up a unit. An assembly drawing is intended to enable a properly equipped machine shop to construct the finished assembly from the prescribed parts.

Detail drawings—When you disassemble a piece of equipment, you eventually get down to individual pieces that cannot be disassembled further. These individual pieces are represented by detail drawings. They give all the information that a properly equipped machine shop will need to make the piece exactly as required.

Wiring drawings—The main purpose of a wiring drawing or diagram is obvious from its name—it shows you how a piece of equipment or a system is wired. There are several varieties of wiring diagrams.

An external (or interconnecting) wiring diagram shows how an item of equipment is connected to the ship's wiring system or to other pieces of equipment. It shows terminal boards, binding posts, plugs, jacks, and other connection points and devices. Letters and numbers identify these components, and lines denote the electrical conductors to be installed. The diagram shows the size, type, and length of wire to be used. The kind of insulation, shielding, duct work, and armoring specifications are noted. The diagram also specifies the kind of current (a.c. or d.c.), frequency, and voltage for each conductor.

An internal wiring diagram does the same for the wiring inside an equipment. It locates and identifies (with standard symbols) all electrical components within the equipment. Fuses and other circuit protection devices are identified by size and type. The diagram also shows all terminals and wiring connection points. Internal wiring diagrams are some of the most useful kinds of drawings for electrical maintenance and troubleshooting.

An elementary wiring diagram is about halfway between the diagrams just discussed and a schematic. Elementary diagrams show terminal and connection points, component locations, values, and so on. They are arranged so circuits can be followed and understood easily. But, like a pure schematic, an elementary diagram has little respect for the actual size and shape of equipment parts. That also applies to the physical location or orientation of the components. The traceability of the circuit is the more important consideration.

Schematic drawings—The primary purpose of a schematic drawing or diagram is to help the user understand the functioning of the equipment. Electric, hydraulic, and pneumatic schematic drawings are of great importance in assisting you as a repairman. Schematics often have little to do with the actual physical appearance or construction of the equipment diagrammed.

Lubrication drawings—A lubrication drawing or chart for naval equipment is often a general arrangement drawing. It can also be a group of these drawings showing several views. The lubrication fittings and other points are called out by labels. The OPs of older equipments normally have lube charts in their appendixes.

List of drawings (LDs)—A list of drawings is treated as an engineering drawing. In a sense, LDs are the key to the drawing system used by NAVSEA. A master LD is prepared for each major ordnance equipment (such as a GMLS). This list identifies all the components of the equipment concerned. Each major component is then itemized by its assemblies, subassemblies, and details on a separate LD.

The identifying number for a component LD is given, together with the general arrangement drawing number, on the master LD. By referring to the list of drawings for a given assembly or subassembly, you can locate individual parts. You can then identify the correct nomenclature, drawing, piece number, design dimensions, tolerances, and all other necessary information. Component LDs also show the special tools required to service the equipment.

HOW TO USE DRAWINGS

When we talk about drawings or engineering drawings, we usually refer to an assembly, subassembly, or detail type of drawing. Such drawings, as we have seen, explain how to manufacture some part or assembly. They are also valuable guides in overhauling and repairing equipment. These drawings show how parts fit together and describe the fastening hardware needed. They show the minor, but essential, parts that an assembly must have so it will continue to function as the designer intended. A watertight enclosure will leak if it does not have the exact gasket called for in the drawing. Screws may loosen if they have not been assembled with the lockwashers specified in the drawing. Nuts will work free if they have not been secured with the cotter pins listed in the drawing.

The other types of drawings are equally valuable. General arrangement drawings are good references for the exact nomenclature of major units. They also serve as guides to other drawings of component assemblies. Installation and outline drawings contain the information on clearances and dimensions personnel need when installing a new piece of equipment. These drawings also show how to arrange the piping and wiring to be connected to the equipment. External wiring diagrams show how to hook the equipment into the ship's wiring. After installation, these diagrams help in troubleshooting for faulty circuits and malfunctioning components. They also are useful in electrical alignment of synchros and other data transmission systems. Internal wiring diagrams are valuable for making circuit checks in case of trouble in the equipment. Elementaries are helpful in training personnel and can be used in checking circuits. The LDs are valuable guides in tracking down information concerning the equipment.

Every ship carries copies of drawings on its installed equipment. The drawings may be in the form of blueprints, photoprints, or microfilm.

These copies are assembled into sets, and each set covers one item. Photoprints are usually bound in books. Aboard ship, blueprints and photoprints are both called ordnance drawings. The use of microfilm will be covered later in the text. These drawings are available to you; make use of them. They will help you become familiar with the equipment you must overhaul and maintain. (Remember to treat Confidential drawings as you would any other Confidential publication.)

In the lower right-hand corner of each drawing you will find a "drawing number." On each detail pictured in the drawing, you will find another smaller number. These are "piece numbers" and identify the hardware on the drawing. Sometimes you will find a letter after the piece number. It shows how many times that piece has been changed or modified since its original design.

Every part of every ordnance device (unless it is very small) has a part number stamped on it. The first number is the drawing number; the second is the piece number. For example, you will find part numbers like 120460-2. Read that "drawing number 120460, piece number 2." Look for these numbers and use them. Refer to them when you report on a particular piece or when you order new parts.

LUBRICATION

As a youngster, did you ever have a wagon or bicycle with squeaky wheels? A squirt or two of oil usually stopped the noise and made the wheels spin or turn better. The oil, acting as a lubricant, made the parts move easier, run smoother, and last longer.

The proper lubrication of ordnance equipment is an extremely important part of your maintenance responsibility. Therefore, you need a general understanding of lubricants and lubrication techniques. The master reference for this subject is *Lubrication of Ordnance Equipment,* NAVSEA OD 3000. Every work center should have a copy of OD 3000. Be sure to consult it.

PURPOSE OF LUBRICANTS

In ordnance systems, lubricants serve many different purposes. The three most important purposes are to (1) reduce friction, (2) dissipate heat, and (3) prevent corrosion.

Friction is present whenever contacting surfaces of mechanical parts are in motion. Friction is a force that resists motion and increases wear. It can be greatly reduced by using a lubricant. Various factors determine the selection of a proper lubricant. Load pressures, operating speeds, and operating temperatures are three primary considerations. Properly applied, the lubricant separates the contacting surfaces with a thin film of oil or grease.

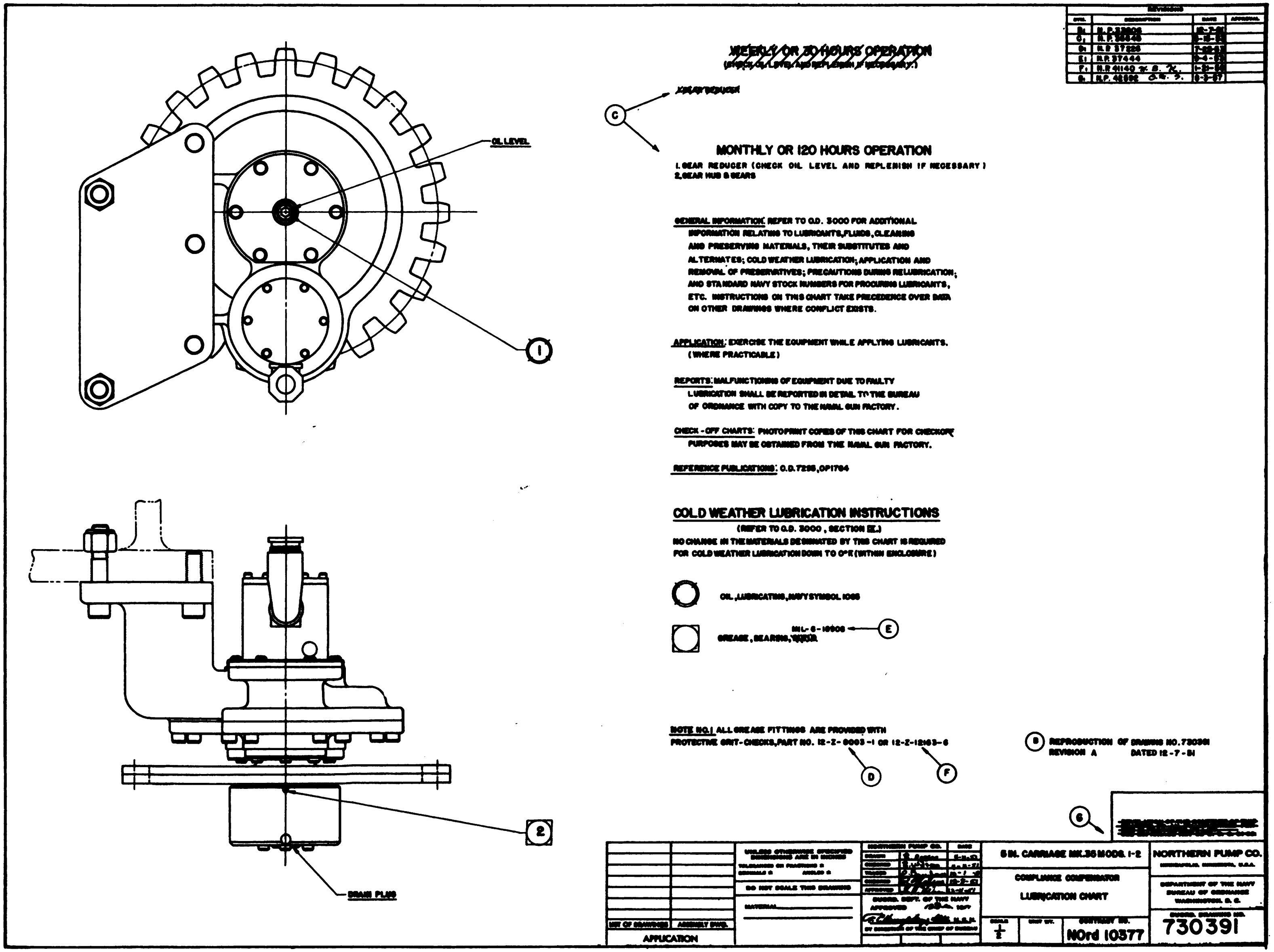
Friction also generates heat; rub your hands together quickly to demonstrate this fact. Ball or roller bearings and high-speed gear trains are very susceptible to heat damage. The heat produced from friction must be dissipated to reduce equipment failures. Lubricant circulation or forced-feed systems are often used for this purpose. Oil is preferred as a bearing lubricant because of its fluidity. (Fluidity is a substance's property that enables it to flow.) Grease may be required where lubricant retention is a problem.

Over-lubrication is just as bad as too little or no lubrication. Excess lubricant acts as an insulating blanket around moving parts and, thus, prevents the heat from escaping. The excess lubricant may "melt," overflow into adjoining equipment, and cause more damage. To ensure a lubricant performs its intended job, lubrication instructions specify the correct amount to be used. Follow those instructions very carefully.

The corrosion-inhibiting properties of a lubricant are as important as its lubricating properties. A lubricant is applied to a metal surface to protect it from the effects of moisture and to retard corrosion. Again, various factors determine the selection of the proper lubricant. Temperature and pressure fluctuations are important considerations. The lubricant must also be capable of remaining on the surface under adverse conditions. Certain lubricants will contain corrosion inhibitors and additives. These "extra ingredients" serve to improve the lubricant's stability and other properties.

LUBRICATION INSTRUCTIONS

Lubrication instructions are provided for all ordnance equipments. These instructions are issued on/in maintenance requirement cards, lubrication charts, ordnance publications, or combinations of these documents. The most popular format is the MRC. However, you may



~~WEEKLY OR 30 HOURS OPERATION~~
~~(CHECK OIL LEVEL AND REPLENISH IF NECESSARY.)~~

MONTHLY OR 120 HOURS OPERATION
1. GEAR REDUCER (CHECK OIL LEVEL AND REPLENISH IF NECESSARY)
2. GEAR HUB & GEARS

GENERAL INFORMATION: REFER TO O.D. 3000 FOR ADDITIONAL INFORMATION RELATING TO LUBRICANTS, FLUIDS, CLEANING AND PRESERVING MATERIALS, THEIR SUBSTITUTES AND ALTERNATES; COLD WEATHER LUBRICATION; APPLICATION AND REMOVAL OF PRESERVATIVES; PRECAUTIONS DURING RELUBRICATION; AND STANDARD NAVY STOCK NUMBERS FOR PROCURING LUBRICANTS, ETC. INSTRUCTIONS ON THIS CHART TAKE PRECEDENCE OVER DATA ON OTHER DRAWINGS WHERE CONFLICT EXISTS.

APPLICATION: EXERCISE THE EQUIPMENT WHILE APPLYING LUBRICANTS. (WHERE PRACTICABLE)

REPORTS: MALFUNCTIONING OF EQUIPMENT DUE TO FAULTY LUBRICATION SHALL BE REPORTED IN DETAIL TO THE BUREAU OF ORDNANCE WITH COPY TO THE NAVAL GUN FACTORY.

CHECK-OFF CHARTS: PHOTOPRINT COPIES OF THIS CHART FOR CHECKOFF PURPOSES MAY BE OBTAINED FROM THE NAVAL GUN FACTORY.

REFERENCE PUBLICATIONS: O.D.7295, OP1764

COLD WEATHER LUBRICATION INSTRUCTIONS
(REFER TO O.D. 3000, SECTION IX.)
NO CHANGE IN THE MATERIALS DESIGNATED BY THIS CHART IS REQUIRED FOR COLD WEATHER LUBRICATION DOWN TO 0°F (WITHIN ENCLOSURE)

○ OIL, LUBRICATING, NAVY SYMBOL 1065

▢ GREASE, BEARING, MIL-G-10908

NOTE NO. 1 ALL GREASE FITTINGS ARE PROVIDED WITH PROTECTIVE GRIT-CHECKS, PART NO. 12-Z-8003-1 OR 12-Z-12163-6

REPRODUCTION OF DRAWING NO. 730391
REVISION A DATED 12-7-51

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Figure 10-2.—A typical lubrication chart showing points of lubrication, types of lubricants, frequency of lubrication, and other instructions.

encounter lubrication charts when dealing with older and auxiliary equipments.

Lubrication charts are prepared on drawing forms and have an assigned number. Figure 10-2 shows a typical lubrication (or lube) chart. Such charts are easier to revise and distribute than ordnance publication drawings. Lubrication charts generally indicate the approved lubricants and related materials needed for the job. Lubrication points, required frequency of application, and target symbols are listed. The charts also contain additional information relating to draining, filling, cleaning, and other maintenance functions.

Table 10-1 shows the target symbols for various lubricants as they appear on MRCs and lubrication charts. In all cases, the specified lubricants should be used. If the specified materials are not available, alternates, substitutes, and emergency substitutes may be used. These materials are identified in OD 3000.

The term "alternate" refers to a material which may be used when a specified material is not available. Lubrication charts or MRC instructions may indicate alternates, and specify the conditions and limitations under which they may be used. A substitute material may be used only if the specified or alternate material is not available. Use of substitutes should always be temporary. They should be replaced by the specified or alternate material as soon as either becomes available. Special cleaning procedures may be required when using substitute or emergency substitute materials.

Emergency substitutes generally differ in many respects from the specified or authorized materials. Thus, emergency substitutes should be used only as a last resort. They must be replaced by the specified or alternate materials as soon as either becomes available. In extreme emergencies or where no substitute has been designated, another material having the closest characteristics to the approved material should be selected. Use OD 3000 to determine this information.

QUALITIES OF LUBRICANTS

Lubricants are of two general classes—oils and greases. Oils are fluids; greases are semisolids at ordinary temperatures. Both have several qualities that determine their suitability for a particular lubrication job. One of the most important qualities is VISCOSITY.

Viscosity is the measure of a liquid's internal resistance to flow. It varies with the temperature as well as with the nature of the substance. Petroleum jelly (Vaseline) can hardly be said to flow at room temperature, but it can be melted to a rather thin liquid. On the other hand, many kinds of oil flow readily at ordinary temperatures, but they become much thicker when cold.

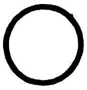
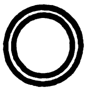
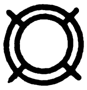
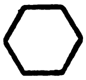
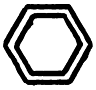
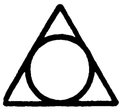
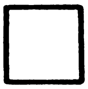
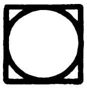
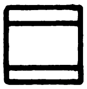
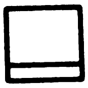
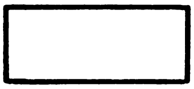
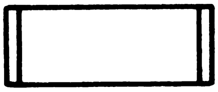
Viscosity is expressed in terms of Saybolt universal seconds (Sus). This measurement represents the number of seconds a given quantity of the lubricant at a specified temperature takes to pass through the Saybolt universal viscosimeter. The higher the Sus number of a lubricant at a given temperature, the more viscous the liquid.

The VISCOSITY INDEX (V.I.) is an indication of the variation of a lubricant's viscosity with changes in temperature. The higher the index number, the less the viscosity varies with changes in temperature. Therefore, a high index is a desirable quality. You want a lubricant that won't solidify and gum up in cold weather, nor liquify and leak away in hot weather. Viscosity index can be improved up to a point by putting chemical ADDITIVES into the oil. (Additives are put in by the manufacturer. Don't try to brew up your own special oil by adding anything to it.)

The FLASH POINT of a lubricant is the temperature at which it gives off flammable vapors. The FIRE POINT (always higher than the flash point) is the temperature at which it will catch fire if ignited. The POUR POINT (of an oil) is the lowest temperature at which it will pour or flow. OILINESS is the characteristic of an oil which prevents scuffing and wear. You might think this depends on viscosity, but a complicated relationship of many factors is involved. Certain substances have been found which increase the oiliness of a lubricant.

CHEMICAL STABILITY concerns a lubricant's ability to "take it." Certain oils and greases tend to deteriorate under influence of high temperatures, exposure to air or water, or introduction of impurities. A lubricant with good chemical stability will resist such deterioration. You can often detect deterioration by noting any changes in the lubricant's color. Also watch for formations of varnish, gum deposits, or sludge. Changes in an oil's viscosity or a grease's consistency (hardening) are other telltale indications of deterioration. These signs mean

Table 10-1.—Target Symbols and Corresponding Lubricants Appearing on Lubrication Instructions

Target Symbol	Name of lubricant	Specification
	Lubricating Oil, Hydraulic and Light Turbine, Noncorrosive	MIL-L-17672B MS 2075 TH
	Lubricating Oil, Hydraulic and Light Turbine, Noncorrosive	MIL-L-17672 MS 2135 TH
	Lubricating Oil, Aircraft Piston Engine	MIL-L-22851 Type III
	Lubricating Oil, General Purpose, Preservative (Water Displacing, Low Temperature)	VV-L-800 (Supersedes 14L17 (Ord))
	Lubricating Oil, Aircraft Instrument, Low Volatility	MIL-L-6085 (Supersedes 14-0-20(Ord))
	Lubricant, Worm Gear	MIL-L-18486 (Supersedes OS 1400)
	Grease, General Purpose	MIL-G-23549 (Supersedes 14G9 (Ord))
	Grease, Aircraft, General Purpose Wide Temperature Range	MIL-G-81322
	Grease, Aircraft and Instrument, Gear and Actuator Screw	MIL-G-23827
	Lubricant, Ball, and Roller Bearing	MIL-G-18709 (Supersedes 14L3)
	Lubricants, Fluids, Preservatives, etc., Other Than Those Indicated Above	As specified
		Used to designate special notes, references, and instructions

that the lubricating and corrosion-preventing qualities of the substances are impaired. You'll find it useful to know the signs of deterioration in oils and greases well enough to recognize them when they appear.

Other qualities or properties of lubricants include dropping point, penetration, neutralization number, work factor, viscosity change, and aniline point. Chemists need to understand the meaning of these terms; we list them only to impress you with the fact that not just ANY oil or grease will do.

TYPES AND PROPERTIES OF LUBRICANTS

Lubricants for ordnance systems are selected on the basis of the characteristics necessary or desired for a particular job. A typical lubricant should have certain qualifications or properties. Several examples are listed below.

1. Maximum reduction of friction between bearing surfaces
2. Corrosion inhibiting properties
3. Stability over a wide temperature range
4. Ability to withstand high pressures
5. Low volatility (tendency to evaporate) at operating temperatures
6. Resistance to oxidation (rust or corrosion)
7. Resistance to emulsification (the unwanted mixing of two incompatible liquids, such as oil and water)
8. Resistance to environmental contamination

For many applications, liquid lubricants such as petroleum or synthetic oils are suitable. That is true if the lubricant can be retained in an oil bath, a gearbox, or in a forced-feed system. Where the oil cannot be readily retained, or additional protection against corrosion is needed, greases are used. In certain applications, equipment operating temperatures are too high for satisfactory lubrication by oils or greases. Then substances such as graphite, molybdenum disulfide, or a bonded dry film made from these materials may be used as the lubricant. If solid or dry film lubricants are used, the bearing surfaces may require pretreatment prior to application. That is necessary to ensure a good adhesion of the lubricant film.

Petroleum-Base Lubricating Oils

Petroleum-base lubricating oils, or mineral oils, are composed mainly of hydrocarbons. The important properties of these oils are their viscosity, viscosity index, pour point, resistance to deterioration, and retardation of corrosion. Additives are used to improve the properties such as viscosity index, pour point, oxidation stability, and corrosion prevention. Viscosity of the oils depends largely on the fraction (or distilled mixture) of petroleum which is selected. Corrosion-inhibited oils should be used where standby storage or continued exposure is involved.

MILITARY SYMBOL OILS.—Military symbol (MS) oils are petroleum-base oils covered by certain military specifications. They contain no corrosion inhibitors. Some of these oils are used in ordnance systems for oil bath, oil can, or forced-feed lubrication. Normally, the equipment involved is enclosed or otherwise protected from corrosive environment.

The symbol used to designate these oils is a four-digit number. The first digit indicates the series or type and the last three digits indicate the approximate Saybolt viscosity. Viscosities are measured at 130°F for all series 2, 8, and 9 oils. All other series are measured at 210°F. The lubricating oil series is as follows:

Series	Type
1	Lubricating Oil, Aircraft Engine
2	Lubricating Oil, General Purpose
3	Lubricating Oil, General Purpose
4	Lubricating Oil, Compounded
5	Lubricating Oil, Cylinder Mineral
6	Lubricating Oil, Compounded
7	Lubricating Oil, Compounded
8	Lubricating Oil, Compounded
9	Lubricating Oil, Diesel Engine

The following examples illustrate the MS system:

1. MS 2135TH—indicates a general purpose oil (series 2) having a viscosity of approximately 135 Saybolt universal seconds (Sus) at 130°F.

2. MS 4065—indicates a compounded oil (series 4) having a viscosity of approximately 65 Sus at 210 °F.

Many MS oils correspond in viscosity ranges to certain Society of Automotive Engineers (SAE) numbers. However, SAE numbers constitute a classification in terms of viscosity only. They do not consider other characteristics or quality factors. Therefore, SAE oils should not be substituted for MS oils except in emergency situations. Consult OD 3000 for a comparison of SAE and MS oils.

Generally, MS oils are intended for use where

- temperatures within the equipment do not exceed 250 °F or fall below 0 °F in normal operation.
- ambient temperatures are between 0 °F and 150 °F.
- protection against corrosion is adequate without inhibitors.
- loads are within moderate limits.
- provisions are made for the retention, replenishment, or circulation of the oil.

PETROLEUM-BASE OILS WITH CORROSION INHIBITORS.—Certain petroleum-base oils contain corrosion inhibitors. These oils provide corrosion protection to metal surfaces and are approved/preferred for use in ordnance systems. They should always be considered for use where short-term preservation is a requirement. In general, these oils may be used at temperatures lower than those for which the MS oils are suitable.

PETROLEUM-BASE GEAR OILS.—Gear oils contain additives to improve their load-carrying properties under extreme pressure conditions. These oils are required to pass performance tests to demonstrate their effectiveness in preventing wear and improving operating efficiency. They are also required to be noncorrosive to copper. Two common gear oils are MIL-L-6086 (a petroleum-base gear lubricating oil) and MIL-L-18486 (a worm gear lubricant).

Graphite-Base Lubricants

These lubricants are composed of oils or other liquids which contain very fine particles of graphite. The graphite is an adherent lubricant. It remains on the metal for some time after the liquid has evaporated or has been burned off. Graphite-base lubricants are approved for specific applications only. An example of a graphite-base lubricant is MIL-G-23398 (an air drying solid film lubricant).

Synthetic Oils

Synthetic oils are largely or entirely composed of synthetic (man-made) materials. They provide satisfactory lubrication and corrosion prevention under conditions where petroleum-base lubricants are unsuitable. Some synthetic ester oils have a deteriorating effect on rubber materials, certain insulators, and organic coatings. Therefore, take care before substituting synthetic lubricants for petroleum-base lubricants. Synthetic oils generally contain corrosion inhibitors and oxidation retardants. An example of a synthetic oil is MIL-L-6085 (a low volatility aircraft instrument lubricating oil).

GREASES

Lubricating greases are used in applications where the use of fluid lubricants is not feasible. For example, space and weight limitations within an equipment may prevent the use of fluid/liquid reservoirs. A suitable lubricating grease provides necessary extended lubrication because of its retention properties. In certain applications, fluid tight seals are not possible with liquid lubricants. Greases will form a seal and provide protection against contaminants. This sealing is of special importance for bearings which operate in wet or dirty areas. Greases also are used to replace fluid lubricants when the part to be lubricated (such as a bearing) is not accessible. Often, in such cases, the quantity of grease in the bearing is expected to provide lubrication for a long period.

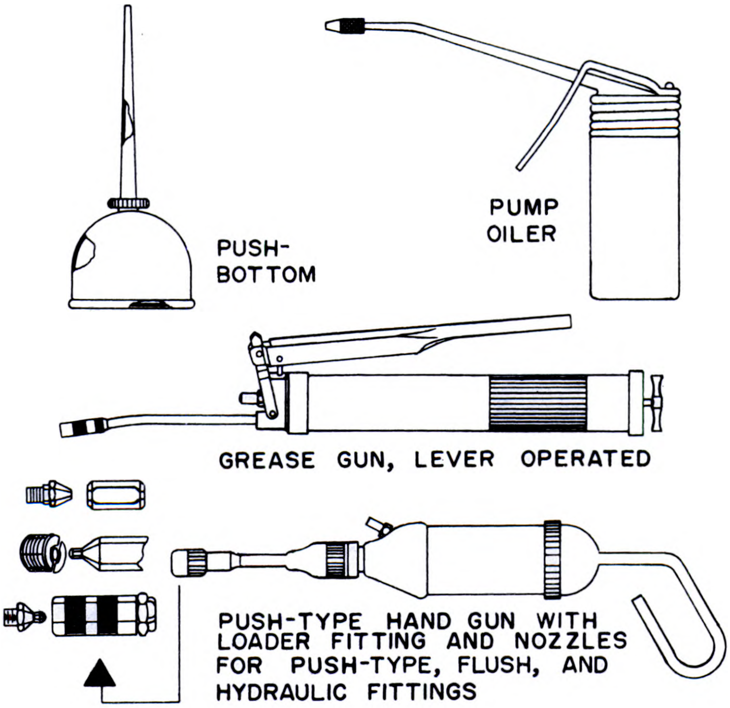
Greases are mixtures of lubricating fluids and suitable thickening agents. The fluids (oils) may be petroleum-base, synthetic, or mixtures of these. Soaps such as aluminum, lithium, sodium, calcium, and barium may be used as thickening agents. The purpose of the soap is to make the oil "stay put" at the point of application. The soap simply traps the oil within its mass. The actual lubrication is done largely by the oil in the grease. You might think of it as an oil-soaked sponge. The heat of friction "squeezes" the sponge, melts the grease, and releases the oil to perform the lubrication.

Greases containing lithium or sodium soaps usually have higher dropping points. A dropping point is the temperature at which the grease passes from a plastic to liquid state. Therefore, lithium and sodium-grease soaps are more suitable for use at higher temperatures. Calcium-soap grease is used where the highest water-resistance is required. Generally, the sodium-soap greases are not water-resistant and should not be used in such applications. Lithium-soap greases are used in many applications because of their high degree of stability over a wide temperature range. They also have excellent preservative properties.

To satisfy the high-temperature requirements of some ordnance systems, nonsoap thickeners are required. These thickeners cover a wide range of materials and include treated silica, modified clays, resins of alkyl urea type, and dyes. Most lubricating greases contain various types of additives. These substances either modify the structure, change the color, or improve the performance of the finished grease. The added agents may include antioxidants, extreme pressure agents, viscosity index improvers, and rust preventives. Most greases afford protection against corrosion and may be used as preservatives as well as lubricants.

LUBRICATING DEVICES

Lubricating oils and greases can be applied to the equipment in various ways. Exposed surfaces generally require a "light coat" of lubricant. Your fingers or a paint brush are normally used to apply the lubricant in these situations. If the lubricant must be put into the equipment, oil cans, grease guns, and appropriate lubrication fittings are needed. Figure 10-3 illustrates a few of the more popular lubricating devices in use.


PUSH-
BOTTOM
PUMP
OILER
GREASE GUN, LEVER OPERATED
PUSH-TYPE HAND GUN WITH
LOADER FITTING AND NOZZLES
FOR PUSH-TYPE, FLUSH, AND
HYDRAULIC FITTINGS

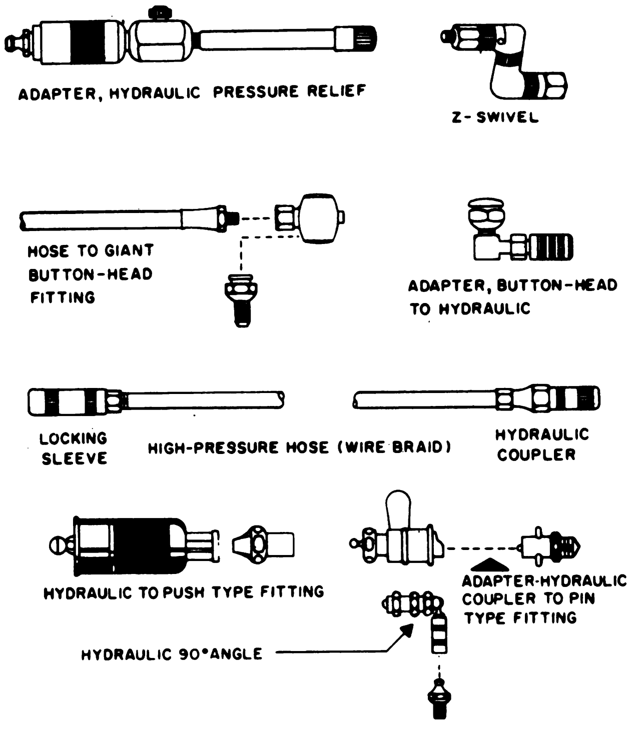
83.120.1

Figure 10-3.—Typical hand-operated lubricating tools.

Grease guns are usually available with a variety of helpful accessories (figure 10-4). Flexible hose assemblies make lubricating those hard-to-reach fittings a little easier. Adapters can be attached to the grease gun's hose to make it compatible with the different lubrication fittings also.

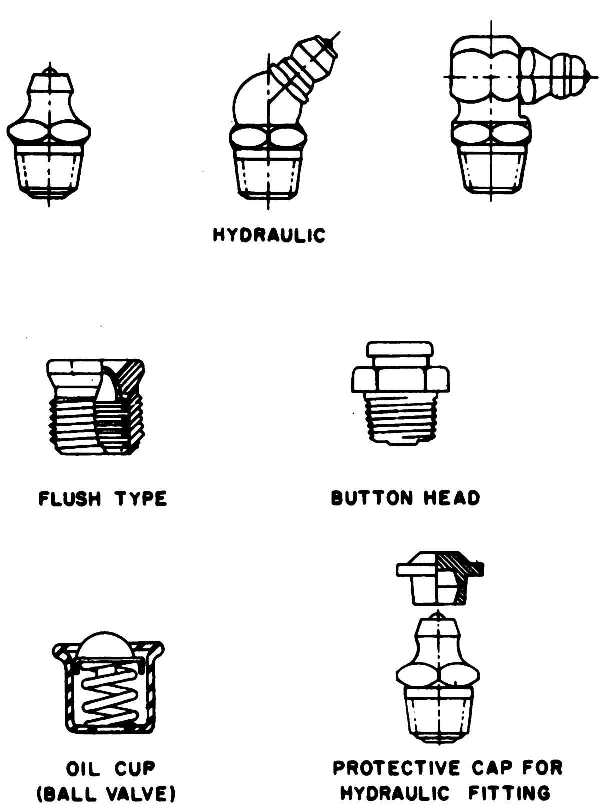
The hydraulic, or zerk fitting (figure 10-5) may be the most common type of grease fitting in use. It screws into the equipment and has a specially rounded end (head) that can be gripped by a grease gun's nozzle (hydraulic coupler). The nozzle will not slip off during lubrication, but can be easily disengaged with a quick forward-backward movement. A spring-loaded ball inside the fitting's head acts as a check valve. It keeps foreign matter out of the fitting and the equipment.

Flush-type fittings are used where protruding types of fittings might be damaged or would interfere with moving parts. The flush, buttonhead, and pin-type fittings are commercial items. One type of oil cup used on ordnance equipment is the ball valve type shown in figure 10-5. Oil cups should be removed and cleaned periodically to remove deposits which result from a combination of long standing under pressure and oil separation.


ADAPTER, HYDRAULIC PRESSURE RELIEF
Z-SWIVEL
HOSE TO GIANT BUTTON-HEAD FITTING
ADAPTER, BUTTON-HEAD TO HYDRAULIC
LOCKING SLEEVE
HIGH-PRESSURE HOSE (WIRE BRAID)
HYDRAULIC COUPLER
HYDRAULIC TO PUSH TYPE FITTING
ADAPTER-HYDRAULIC COUPLER TO PIN TYPE FITTING
HYDRAULIC 90°ANGLE

83.120.2

Figure 10-4.—Hose assemblies and adapters.



83.122

Figure 10-5.—Lubrication fittings.

Plastic protective caps are available and offer additional protection for hydraulic fittings. When installed, these caps keep dirt, water, and other contaminants off the head of the fitting. They also tend to prevent the hardening of the grease in the small holes of the fitting. The caps protect the fitting during ice removal, painting, and similar operations. They are reusable, available in several colors, and are inexpensive. Order them by the box and protect your equipment's lubrication fittings.

As with other routine jobs, it helps to have a standard operating procedure you can habitually follow. Here's a simple one that will be helpful in lubricating/greasing your gear:

1. First, consult the lubrication instructions (e.g., MRC, lube chart) and locate the fitting on the equipment.
2. Remove the protective cap and clean the fitting carefully with a lint-free cloth.
3. Apply the correct amount of the specified lubricant. Be careful of the amount you apply. Too much may cause an excessive heat buildup and strain the grease retainers; too little is on a par with too late.
4. Wipe all excess grease from around the fitting and reinstall the protective cap.
5. Check off the fitting so it is not missed or forgotten.

POWER-TRANSMISSION (HYDRAULIC) FLUIDS

Certain fluids (oils) are preferred as the power-transmission media in ordnance equipment. These hydraulic fluids contain additives to improve specific characteristics of their chemical and physical properties. Of main concern is the fluid's ability to transmit power and amplify force within a hydraulic system. The approved power transmission fluid for virtually every GMLS CAB-type power drive system is designated MIL-F-17111.

Characteristics

Power-transmission fluids, such as MIL-F-17111, are refined petroleum oils or blends of refined petroleum oils containing additives. The additives inhibit corrosion and oxidation, improve viscosity index, and enhance wear-resistant properties. The additives in MIL-F-17111 remain uniformly distributed at all temperatures from the fluid's pour point to 150 °F. Normally, the highest operating temperature of the fluid should not exceed 190 °F. Exercising the hydraulic system for 15 minutes before service operation generally results in improved operation under cold weather conditions. With such exercising, MIL-F-17111 can be used at temperatures as low as -20 °F.

Power-transmission fluids must be chemically stable and nonfoaming. They must have a high viscosity index, adequate lubricating properties, a low pour point, good heat-transfer properties, and low compressibility. They must have no harmful effects on and not be affected by the metal parts of the system. They also must be compatible with and have minimum chemical effect on the organic materials used for packing, seals, and gaskets.

Power-transmission fluids have a tendency to leak through small openings or scratches. To minimize leakage, the machined parts of hydraulic systems must have a smooth finish. Much work has been done to improve the quality of seals, flanges, and fittings. Despite these improvements, hydraulic systems require careful assembly and constant maintenance to prevent leakage.

Power-transmission fluids must contain corrosion inhibitors to protect metal parts from water. The inhibitors are not efficient corrosion preventives for long-term (idle) storage. In drained systems, where only a thin film of fluid remains, power-transmission fluids offer temporary protection only.

The approved power-transmission fluids usually contain antiwear additives. Their lubricating properties are adequate to prevent wear in well-designed hydraulic systems. However, these fluids are not intended for use as general-purpose lubricating oils.

Alternates and Substitutes

Here we must make a very important point about alternate and substitute materials for power-transmission fluids, especially MIL-F-17111. Essentially there are no substitutes!

Lubricating oils MIL-L-17672, MS2110TH, and MS2135TH are fluids classified as emergency substitutes for MIL-F-17111. Except in cases of extreme tactical emergencies, the MS oils and MIL-F-17111 must not be combined. These fluids are not compatible and mixing them may result in sludging. If emergency substitution is necessary, the hydraulic system must be completely drained and flushed before the substitution. The same draining and flushing procedure is followed when returning the hydraulic system to normal condition. This action should be done as soon as possible.

Cleanliness

The cleanliness of a power-transmission system and its interconnected hydraulic controls is very critical. For optimum performance, the system must be substantially free of all contaminants. That includes water, dirt, insoluble products resulting from oxidation of the hydraulic fluids, corrosion products, and metal particles. Presence of these contaminants can cause damage to the working surfaces of the operating components and may clog filters. Severe contamination also can result in erratic equipment performance and/or complete failure.

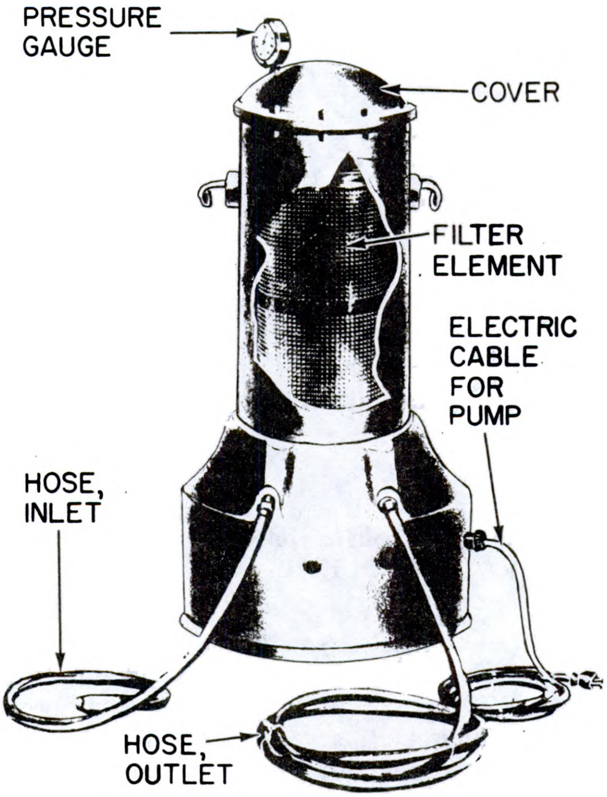
Take special precautions to protect the system from water. Water may enter the system by condensation of moisture in the air. Rain or salt spray can enter through unsecured filler caps, plugs, or cover and inspection plates. Water is especially harmful when the system is inactive. The water will corrode metal surfaces in the bottom of expansion tanks and at low points in system piping. It also decreases the lubricating efficiency of the fluids and reacts with the additives contained in the fluids. Deposits may form which will give the fluid a slightly milky-white or cloudy appearance. Corrosion or precipitation products can form sludge on the surfaces of the internal components of the system. The sludge can cause these components to stick, and may clog the filters in the system.

To prevent these harmful effects, follow the specific instructions for maintaining and cleaning the equipment. For example, before filling/replenishing a hydraulic system, strain the fluid through a No. 200 (74 micron) sieve. Use of a finer sieve is better. This straining process helps remove the coarse particles that may be present even in new fluid.

Draining and Refilling

Periodically, you will be required to draw hydraulic fluid samples from your system. After the filled sample botles are properly packaged and marked, they are sent to a test laboratory. The laboratory analyzes the fluid samples and supplies a report to you and NAVSEA.

If the hydraulic fluid is found to be contaminated, it must be drained from the system. Instructions for this operation are provided on MRCs or in the equipment's OP. Follow the instructions carefully. Usually the system must be operated/warmed up for an hour or two, which helps the draining process. Do not discard the old fluid unless you are authorized to do so. Sometimes it can be "saved" and reused by passing it through a special filtering machine, commonly called a renovator (figure 10-6).



5.17(84A)

Figure 10-6.—Portable filtering equipment; renovator.

Normally, new or renovated hydraulic fluid will be used to clean the system if flushing is required. Special flushing compounds are available, but consult the maintenance instructions before using them in your system.

After the system is drained and (possibly) flushed, it must be refilled. Always use the hydraulic fluid specified and filter/strain it before putting it in the system. During any refilling operation, it is almost impossible not to trap some air within the system. Next to contamination, air is a hydraulic system's worst enemy. Since air is very compresible, it can change the whole character of a system's operation.

Most hydraulic systems have features which automatically vent air trapped within their lines and components. Breather tubes extending from the top of fluid supply tanks is one such method. Located at other high points throughout a system are air-vent ports or plugs. These plugs must be opened manually while the system is under pressure. Carefully and slowly crack the vent plug open and watch for air bubbles in the fluid as it leaks out. Close the plug when there are no more air bubbles venting. Repeat the procedure for all the air-vent plugs in the system.

To ensure their reliability, GMLS hydraulic systems must be well maintained. Generally, the work involved is neither complex nor time-consuming. However, the BEST form of maintenance for a hydraulic system is quite simple—EXERCISE THE EQUIPMENT DAILY. A 5- or 10-minute workout each day keeps the GMLS's hydraulic fluid in circulation. As a result, all seals and gaskets are kept moist and in good condition. Hydraulic valves are lubricated so they move freely and do not stick. Dirt and other foreign particles can be screened from the fluid as it passes through the system's filters. Water (from condensation) will evaporate as the system warms up and air will be purged through breather tubes. An idle hydraulic system is an open invitation to many maintenance problems. Daily exercise helps prevent such problems from happening.

CORROSION CONTROL

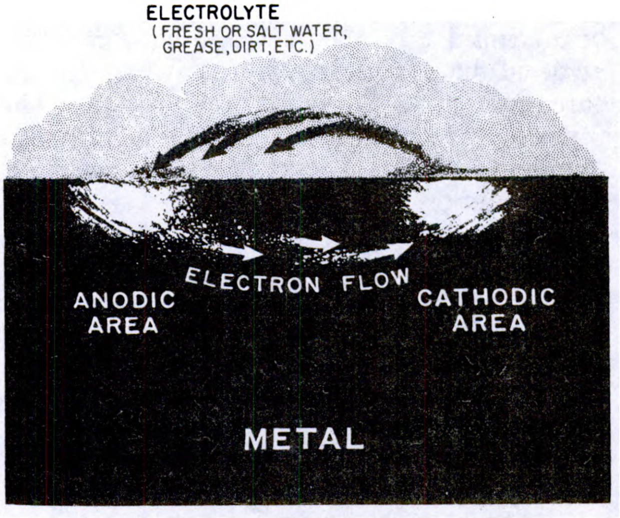
A major threat to the structural integrity and operational readiness of ordnance systems is metal corrosion. The materials used in constructing our equipments are designed to carry certain loads and to withstand given stresses and pressures. Corrosion tends to reduce the strength and mechanical characteristics of these materials/parts. Left unchecked, severe corrosion is very dangerous and may affect the safety of the equipment and endanger personnel.

An important part of your maintenance job is to be familiar with the causes of corrosion. You also must be knowledgeable of the cleaning and preservation techniques used to control the effects of corrosion.

METAL CORROSION

Metal corrosion is the deterioration of metals as they combine with oxygen to form metallic oxides. This combining process is commonly known as oxidation. It is caused by either a direct chemical or an electrochemical reaction of a metal with other elements. In the direct chemical attack, the reaction is similar to that which occurs when acid is applied to bare metal. However, in its most familiar form, corrosion is an electrochemical reaction between metal and water.

In the electrochemical attack, metals with different electrical potentials are involved. The metals do not have to be in direct contact for the attack to take place either. When one metal contains positively charged ions and the other contains negatively charged ions, any electrical conductor bridged between them will cause current to flow. The conductor bridge may be any foreign material such as water, dirt, grease, or form of debris that is capable of acting as an electrolyte. Once the electrolyte has completed the circuit, the electron flow is established within the metal (figure 10-7). Eventually, the positively charged area (anode) of the metal is destroyed.



213.49

Figure 10-7.—Simplified corrosion cell.

All preventive measures taken with respect to corrosion control are designed primarily to avoid the establishment of the electrical circuit.

The electrochemical reaction which causes metal to corrode is more serious under wet, humid conditions. The salt in sea water and in the air is the greatest single cause of corrosion. The presence of salt in any electrolyte tends to accelerate the current flow and speed the rate of corrosive attack. Hot climates also speed the corrosion process because the electrochemical reaction develops fastest in a warm solution. Warm moisture in the air is usually sufficient to start corrosion if the metals are uncoated. As would be expected, hot, dry climates usually provide some relief from constant corrosion problems. Extremely cold climates also produce corrosion problems if a salt atmosphere is present. Melting snow or ice provides the necessary water to begin the electrochemical reaction.

Another corrosion factor is in the relationship between the dissimilar metals. Wherever two dissimilar metals are used, they should be insulated from each other to avoid contact. If the insulation fails, the corrosive attack will be quite severe.

Characteristics of Corrosion

There are many factors that affect the type, speed, cause, and the seriousness of metal corrosion. Some of these corrosion factors can be controlled; others cannot. One of the problems involved in corrosion control is recognizing corrosion products when they occur. The following paragraphs include brief descriptions of typical corrosion product characteristics for the more common metals.

IRON AND STEEL.—Possibly the best known and easiest recognized of all forms of metal corrosion is the familiar reddish colored iron rust. When iron and its alloys corrode, dark iron oxide coatings usually form first. These coatings, such as heat scale on steel sheet stock, may protect the iron surfaces rather efficiently. However, if sufficient oxygen and moisture are present, the iron oxide is soon converted to hydrated ferric oxide. That substance is the conventional red rust.

ALUMINUM.—Aluminum and its alloys exhibit a wide range of corrosive attack. This varies from etching of aluminum surfaces to penetrating attacks along the internal grain boundaries of the metal. The corrosion products of aluminum are seen as white to gray powdery deposits.

MAGNESIUM AND ITS ALLOYS.—Magnesium corrosion products are white and quite large compared to the size of the base metal being corroded. The deposits have a tendency to raise slightly, and the corrosion spreads rapidly. When white puffy areas are discovered on magnesium, they require prompt attention. The corrosion may penetrate entirely through the structure in a very short time.

COPPER AND COPPER ALLOYS.—Copper and its alloys are generally corrosion resistant, although the products of corrosive attack on copper are commonly known. Sometimes copper and copper alloy surfaces will tarnish to a dull gray-green color, and the surface may still be relatively smooth. The discoloration is the result of the formation of a fine-grained, airtight, copper oxide crust, called patina. This patina in itself offers good protection for the underlying metal in ordinary situations. However, exposure of copper and copper alloys to moisture or salt spray will cause the formation of blue or green salts. These substances indicate active corrosion. The salts will form over the patina since this crust is not impervious to water (not moistureproof).

Control of Corrosion

Control of corrosion is dependent upon maintaining a separation between susceptible alloys and the corrosive environment. This separation is accomplished in various ways. An intact coat of paint provides good corrosion protection. Sealants are used at seams and joints to prevent entry of moisture into vital areas. Preservatives and lubricants are used on unprotected areas of working parts. Inspection covers, caps, and similar shields are used to provide varying degrees of protection from corrosive media.

However, unfortunately, none of the techniques described in the last paragraph provides 100-percent corrosion protection in the long run. Paint is subject to oxidation and decay through weathering. Sealants may work out by vibration or else be eroded by rain and wind. Preservatives and lubricants at best offer only temporary protection when used on operating surfaces. Coverings are subject to improper installation and neglect.

In short, there are no permanent solutions or magical cures for the problems of corrosion. Therefore, what is the most effective means available to combat and control the effects of corrosion? The answer is YOU. In following an active preventive maintenance program, you must use various materials to protect the surfaces of the equipment.

CLEANING

Before you apply any preservative to an affected surface, the area must be properly prepared. That involves removing any existing corrosion and contaminants by using approved cleaners and cleaning techniques.

Cleaning is the most important step in preparing an unprotected surface for a protective coating application. It does not make any sense to apply a preservative over dirt, rust, or other form of corrosion. Granted, a fresh coat of paint (for example) can make the equipment look pretty. But a quick "cosmetic fix" is generally a waste of time and effort. Cleaning is intended to recondition a deteriorated surface and remove ALL contaminants in the process. The best methods of protection and preservation will be ineffective if an unprotected surface is not cleaned and prepared beforehand.

Cleaning also is an important step after a surface area is preserved. Contaminants such as salt spray, dirt, grime, and the like accumulate on preserved surfaces. If these contaminants are allowed to remain on a surface area, its preservative will be weakened. Eventually, the area corrodes and, if left unchecked, can result in damage that is beyond economic repair.

The main point is simple. Cleaning must be done before and after a preservative is applied to a surface. There are many different types of cleaning materials available to help you do the job. These materials must meet certain military specifications and are compounded to accomplish definite results. A few of the more popular cleaning agents are briefly discussed in the next two topic areas.

Solvents

Cleaning solvents are liquids which dissolve other substances. There are a number of different solvents, but for cleaning purposes, organic solvents are most often used. Some solvents are chlorinated. When solvents contain more than 24 percent by volume of chlorinated materials, they must be kept in specially marked containers. Take care to ensure that the fumes from these solvents do not escape into work spaces. All personnel working with or near chlorinated solvents should be particularly careful to avoid inhaling these vapors. While the vapors from some solvents are more toxic than others, prolonged exposure to any solvent fumes can be injurious to health.

In addition to the breathing hazard associated with solvents, they also present varying degrees of fire and explosion hazards. Solvent cleaners having a flash point greater than 105 °F (41 °C) are relatively safe. Solvents having flash points below 105 °F require special precautions.

Another hazard associated with solvents, and to a certain extent with all cleaning materials, is the effect of the surface or material being cleaned. Some solvents will deteriorate rubber, synthetic rubber, asphaltic coverings, and so on. This is such an important consideration that you must always take it into account when selecting cleaning materials. Certain cleaning materials may do a good job in removing dirt, grease, oil, and other deposits. But they might damage the object being cleaned or ruin otherwise good paint coatings.

Cleaning solvent P-D-680 is a water-clear petroleum distillate liquid commonly used as a dry-cleaning fluid. It is furnished in two types, I and II. Type II has the higher (safer) flash point and is intended for shipboard use. It is used as a general all-purpose cleaner for removing oils and greases from metal surfaces. The solvent may be applied by spraying, brushing, dipping, and wiping. After cleaning a surface with solvent, dry the area and apply lubricants and preservatives immediately. The solvent itself does not offer any protection against corrosion.

Other Cleaning Materials

For the most part, you will use some type of solvent for cleaning purposes. However, there are other cleaning materials available and maintenance instructions will specify their use.

Emulsion cleaners, for example, differ from solvent cleaners in their action on the contaminants. With solvents, the contaminants go into solution (dissolve) with the cleaning material. Emulsion cleaners tend to disperse contaminants into tiny droplets which are held in suspension in the cleaner. Use emulsion cleaners with care since some are flammable and toxic and, like solvents, may damage paint or other finishes.

There are various soaps and detergents available for mild cleaning on painted and unpainted surfaces. These materials can remove light-to-medium soils, operational films, and light coats or smudges of oils and greases. Unless otherwise specified, most soaps and detergents are safe to use on all surfaces including fabrics, plastics, and so on.

Chemical cleaners must be used carefully. The danger of entrapping corrosive chemical materials between layers of metal and at seams is very possible. This counteracts any advantages in the speed and effectiveness of the chemical cleaner. All materials used must be relatively neutral and easy to remove. Remove residues from this type of cleaning completely. Soluble salts from chemical surface treatments will liquefy and promote blistering in paint coatings.

PRESERVATION

The equipment must have suitable protection against corrosive attack. That is achieved essentially by placing a barrier between the cleaned surface that is to be protected and any possible source of moisture. During manufacture or overhaul, protective barriers such as electroplate, paint, or chemical surface treatment are provided. Surfaces that cannot be so treated, and in some instances the treated surfaces themselves, must be covered with special corrosion-preventive compounds. The protection these compounds give is effective only if no moisture, dirt, or active corrosion is present on the treated surface. The equipment, therefore, must be clean and dry before a preservative compound is applied. An unbroken film of preservatives must be applied in an atmosphere as moisture-free as possible.

Compounds alone do not provide complete protection. Tapes, barrier paper, and other devices can be used to seal off openings in the equipment. If such openings were allowed to remain open during longtime stowage, they would permit the entry of moisture and dirt. To provide additional protection against corrosion, a complete moisture barrier is sometimes provided. Internal areas that have been sealed off can be dehydrated by installing desiccants (moisture absorbents) to remove entrapped moisture. When an area cannot be sealed adequately, provision must be made for ventilation and moisture drainage.

In general maintenance, preservation can assume two meanings. First, it supplements the protective coating already present. Second, it provides temporary protection to equipment areas by the use of various protective coatings and barrier materials.

The oils and greases used as lubricants in general maintenance procedures often have some corrosion-retarding and corrosion-inhibiting properties. In certain situations, nonlubricating preservatives are used. They offer very good protection, but little or no lubrication. Unless otherwise specified, the nonlubricating preservative must be removed before a new lubricant or hydraulic fluid is applied. The equipment may be damaged if the preservative is not removed.

CLEANING AND PRESERVATION PRECAUTIONS

Observe the following general precautions to prevent damage to the equipment during cleaning and preservation operations.

1. Ensure cleaning and preservation methods and materials are used according to current maintenance instructions.

2. After an unpainted metal surface has been cleaned and dried, do not handle it. If you must handle the surface, use rubber gloves or some other mechanical means. Perspiration from your hand is extremely corrosive and can contaminate the metal surface.

3. After a preservative has been applied to a surface, avoid handling it. The integrity of the protective coating will be damaged.

4. Bare metal surfaces tend to corrode very quickly. Apply preservatives as soon as possible after cleaning.

5. Slight changes in temperature and humidity may cause condensation to form on a cleaned surface. Do not apply a preservative to a wet surface. The protective film will trap the moisture and corrode the surface under the film. Dry the surface thoroughly before applying the preservative. In certain cases, a water-displacing compound can be used before the preservative is applied.

6. If at all possible, clean and preserve disassembled equipment indoors. Postpone outdoor preservation work during inclement weather.

TOOLS

The most valuable maintenance skill you can have is a knowledge of tools. Knowing which tools to use and how to use them properly is essential. Tools are designed to make the job easier and enable you to do a task more efficiently.

An excellent reference on tools is the training manual entitled *Tools and Their Uses,* NAVPERS 10085 series. It describes the basic handtools, power tools, measuring tools, and miscellaneous fastening hardware common throughout the Navy. The manual also explains how these devices should be used and emphasizes many safety rules. Be sure to consult this manual. You will find it very informative.

The information presented in this text will amplify selected areas of *Tools and Their Uses.* Primarily, we will concentrate on the techniques for using certain tools properly and repeat the more important safety precautions. In general, you should keep the following points in mind when dealing with any tool.

1. Refer to a tool by its proper and specific name. Trade and slang names are often used to identify tools, but this can become confusing. Use the correct terminology.

2. Choose the proper tool for the job and then use the tool correctly. For example, a wrench is not a hammer and a screwdriver is not a pry bar. Incorrect use of a tool can ruin it, and may result in equipment damage or personnel injury. Essentially, a tool has only one specific purpose; use it for that purpose only.

3. Protect and care for all tools to ensure they are in proper working order. Good quality tools are a costly investment and they must be kept in top-notch condition.

4. Clean, inspect, and inventory your tools after you finish a job. Always return your tools to their proper storage place after use. The next time a tool is needed, you (and other work center members) will be able to locate it easily.

5. On the job, keep your tools well-organized and within easy reach. Do not place or rest a tool where it might fall into open equipment. If the tool is not recovered and the equipment is energized or operated, serious damage could result. In short, use common sense, ask questions if in doubt, and think tool safety.

THE BASIC HANDTOOLS

It is likely that you already have some experience with basic handtools. Many of these items are found around the average home. They include the common varieties of hammers, pliers, screwdrivers, and so forth.

In ordnance work, the basic handtools are the most important maintenance tools you will use. For this reason, it is vital you (1) understand their purpose, and (2) understand how to use them correctly.

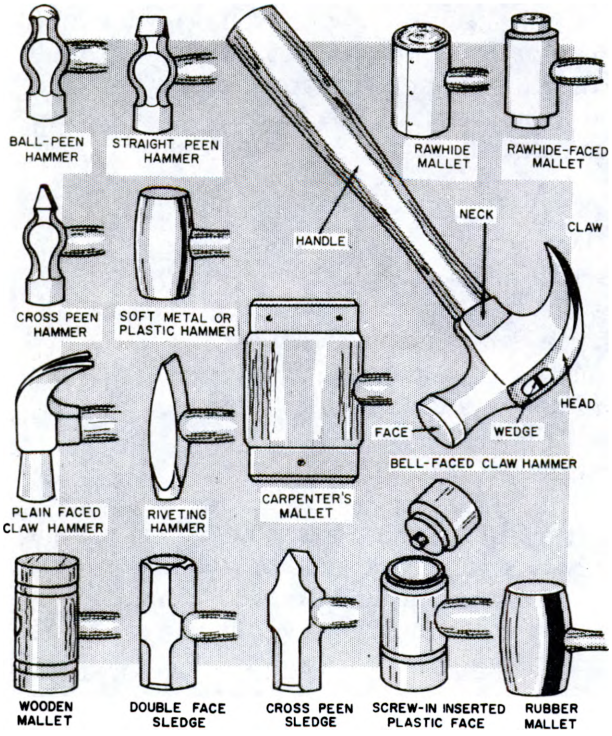
Striking Tools

Hammers, mallets, and sledges are the tools used to apply a striking force. Figure 10-8 illustrates their various styles and shapes. Machinist's hammers (such as ball-peen hammers) are the most popular.

As simple as a hammer is, there is a right way and a wrong way to use it (figure 10-9). Except for light blows/taps, hold the handle close to the end. This increases leverage and produces a more effective blow. Try to hit the object with the full force of the hammer. Deliver a blow so the face of the hammer and the surface being hit are parallel. That will distribute the force of the blow evenly.

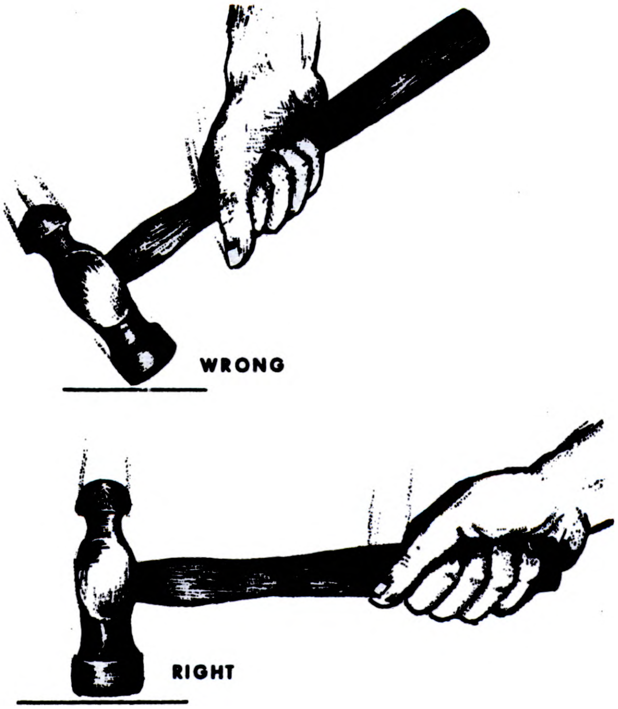
Hammers, mallets, and sledges are dangerous tools if used carelessly and without consideration. Some important points to remember when using a striking tool follow:

- Do not use a hammer handle as a pry bar or to bump/tap parts into assembly. Such abuses can cause the handle to split, which could result in bad cuts, splinters, and other injuries. Should a handle split or crack, do not try to repair it with string, wire, or tape; replace it before continuing to use the hammer.



5.5(44B)A

Figure 10-8.—Hammers, mallets, and sledges.



5.5.1(44A)

Figure 10-9.—The right and wrong way to use a ball-peen hammer.

- Do not strike a hardened steel surface with a steel hammer. Small pieces of steel may break off and cause severe eye injuries. No harm is done if a steel hammer strikes a punch or chisel. The steel in the heads of those tools is slightly softer than the hammer's face.

Turning Tools

Wrenches are considered the basic turning tools. They are used to exert a twisting force on nuts, bolts, studs, and pipes. There are many types, sizes, and styles of wrenches available. In ordnance work, you will use most of the wrenches listed below. *Tools and Their Uses* provides a full description of each item.

- Regular wrenches

  Open-end wrench
  Box end wrench
  Combination wrench

- Socket wrenches (socket sets)
- "Spintite" or nutdriver wrenches
- Allen wrenches
- Adjustable wrenches

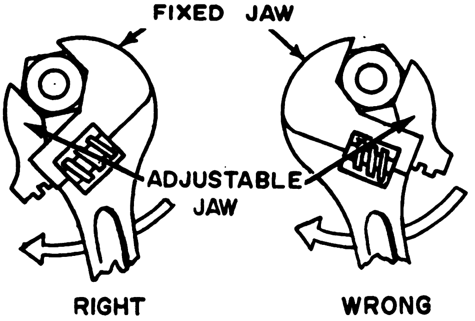
  Crescent wrench ("knuckle buster")
  Monkey wrench
  Pipe (Stillson) wrench
  Chain/pipe wrench
  Strap wrench

- Spanner wrenches
- Torque wrenches

SAFETY RULES FOR WRENCHES.—You must always observe certain rules when using wrenches. For instance, select the best wrench for the job. The pipe, chain, and strap wrenches will rotate or hold round work such as pipes. The "Spintite" or nutdriver (socket) wrench is similar to a screwdriver. This type of wrench is useful for small assembly and electrical work.

When dealing with nuts or bolts, the solid nonadjustable wrenches (e.g., combination wrenches and socket wrenches) are preferred. They provide a snug fit and are less likely to slip off the work. Additionally, these wrenches are built to withstand large amounts of torque.

Crescent and monkey adjustable wrenches have one advantage. They are capable of fitting odd-sized nuts/bolts because they have a movable jaw. Although this feature makes them handy all-purpose tools, adjustable wrenches are not preferred. They are not intended to replace the regular solid wrenches nor are they built for use on extremely hard-to-turn items. If you must use these tools, use them properly. Ensure the jaws are adjusted correctly and pull the handle toward the adjustable jaw (figure 10-10). If you use them incorrectly, the tool will slip off the work and round the flats of the nut/bolt. The slippage also usually results in your busting your knuckles (hence, "knuckle busters").



1.16.6(1)

Figure 10-10.—Proper procedure for pulling adjustable wrenches.

Keep all wrenches clean and free from oil and grease. Lubricants only increase the chances of the tool's slipping off the work. The best way to use any wrench is to apply a steady, firm pressure during the turning motion. Pull a wrench rather than push it. Pushing a wrench is a good way to bust those knuckles (again) should the tool slip or the nut suddenly break loose. If you must push a wrench, do it with an open palm.

Always determine which way a nut/bolt must be turned before trying to rotate it. Generally, most nuts/bolts have a right-hand thread and are turned clockwise to be tightened and counterclockwise to be removed. That may seem obvious, but even experienced technicians get "confused" once in awhile! Take a moment to think the job through first. (Although rare, you may encounter a nut/bolt with a left-hand thread; tightening and removing directions are the opposite.)

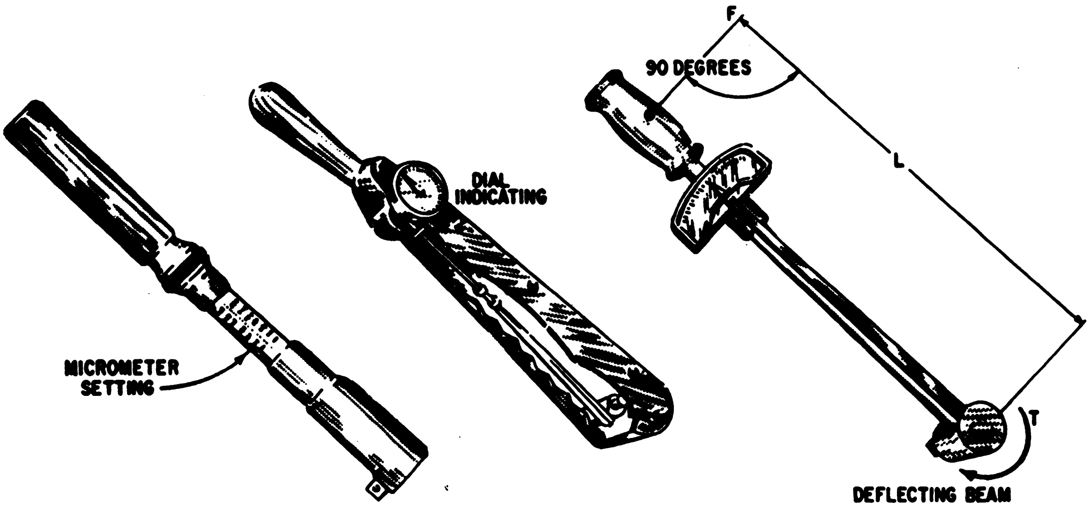
Experience will tell you if you are using the right amount of force on a wrench. A general rule of thumb is to turn the wrench until it has a firm, solid "feel." This "feel" must be developed with practice. Overtightening often results in stripped threads or broken bolt heads.

The leverage on a wrench can be increased to gain more torque for those extremely tight jobs. One method is to slip a piece of pipe over the wrench's handle to increase its length. (Extra leverage devices are commonly called "breaker bars.") This practice is NOT recommended as it essentially overtaxes the designed strength of the tool. However, in certain situations, its use is unavoidable. If you must use a breaker bar for extra leverage (1) use it as a last resort, and (2) use it carefully. Along the same lines, never use a hammer to "tap" a wrench for the same reasons.

TORQUE WRENCHES.—Torque wrenches can be considered special tools and, therefore, will be covered separately. There are times when, for engineering reasons, a definite pressure must be applied to a nut or bolt. In such cases, a torque wrench must be used. The torque wrench is a precision tool consisting of a torque-indicating handle, an adapter, and attachments. It is used to measure the amount of turning or twisting force applied when tightening various nuts, bolts, or machine screws.

The three most commonly used torque wrenches are the deflecting beam, dial indicating, and micrometer setting types (figure 10-11). When using the deflecting beam and dial indicating torque wrenches, you visually read the amount of applied torque on a dial or scale mounted to the handle of the wrench. When using the micrometer setting type, you must first unlock the grip. Adjust the handle to the desired setting on the micrometer-type scale, then relock the grip. Install the required socket or adapter to the square drive of the handle. Place the wrench assembly on the nut or bolt and pull in a clockwise direction with a smooth, steady motion. (A fast or jerky motion will result in an improperly torqued unit.) When the torque applied reaches the torque value indicated on the handle setting, the handle will automatically release or "break" and move freely for a short distance. The release and free travel is easily felt, so there is no doubt when the torquing process is complete.

Maintenance instructions will specify the amount of torque to be applied in a given situation. To get the correct amount of torque on a fastener, you must use the torque wrench properly. Choose a wrench which will read about midrange for the amount of torque to be applied. BE SURE THAT THE TORQUE WRENCH HAS BEEN CALIBRATED BEFORE YOU USE IT. Remember, too, that the accuracy of torque-measuring depends a lot on how the fastener's threads are cut and their cleanliness. Make sure you inspect, clean, and (if required) lubricate the threads.



5.9

Figure 10-11.—Torque wrenches.

Torque wrenches are delicate and very expensive tools. The following precautions should, therefore, be observed:

1. When using the deflecting beam or dial indicating wrenches, hold the torque at the desired value until the reading is steady.

2. When using the micrometer setting wrench, do not move the handle below its lowest torque setting. However, the handle should be placed at its lowest setting when the tool is stored.

3. Do not use a torque wrench to apply greater amounts of torque than its rated capacity.

4. Do not use a torque wrench to break loose/undo tightened nuts or bolts.

5. Do not apply a torque wrench to a nut/bolt that has been tightened. First, back the nut/bolt off one turn with a regular wrench. Then, retighten the nut/bolt to the correct torque with the torque wrench.

6. Never store a torque wrench in a toolbox or other area where it may be damaged.

7. Do not drop or throw a torque wrench. If dropped, the tool's accuracy will be affected. The torque wrench must not be used again until it has been recalibrated.

8. Calibration intervals have been established for all torque tools used in the Navy. When a tool is adjusted/checked by a qualified calibration activity, a label showing the next calibration due date is attached to the handle. This date should be checked before a torque tool is used. If the tool is beyond its calibration due date, do not use it.

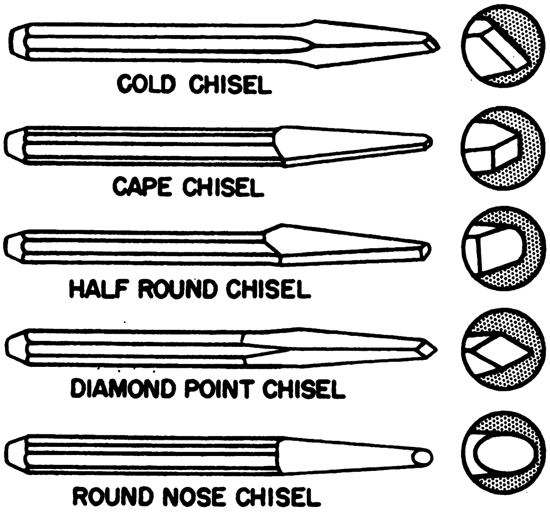
Metal Cutting Tools

There are many types of tools used to cut metal. The three most common metal-cutting tools you will use are chisels, hacksaws, and files. They are often the most abused tools.

Chisels are used for chipping or cutting metal. They are made from a good grade of tool steel and have a hardened cutting edge and beveled head. Figure 10-12 illustrates the more common chisels and point shapes. The flat cold chisel serves to cut rivets, split nuts, chip castings, and cut thin metal sheets. The cape chisel is used for special jobs like cutting keyways, narrow grooves, and square corners. Round-nose chisels make circular grooves and chip inside corners with a fillet. The diamond-point chisel is used for cutting V-grooves and sharp corners.

The correct techniques for using a chisel are discussed below. Select a chisel large enough for the job and use an appropriate sized hammer that matches the chisel. Hold the chisel steady but not tightly. Keep your eyes on the cutting edge of the tool and not on its head. Swing the hammer in the same place as the body of the chisel. Always point the hammer away from your body in case the chisel slips.

Hacksaws are the basic handtool/saw used for cutting metal. Most hacksaws have an adjustable frame to accept different blade lengths. Hacksaw blades are made of high-grade tool steel which is hardened and tempered. The blade can be installed so the cutting teeth are parallel or at right angles to the frame. Properly installed, the teeth

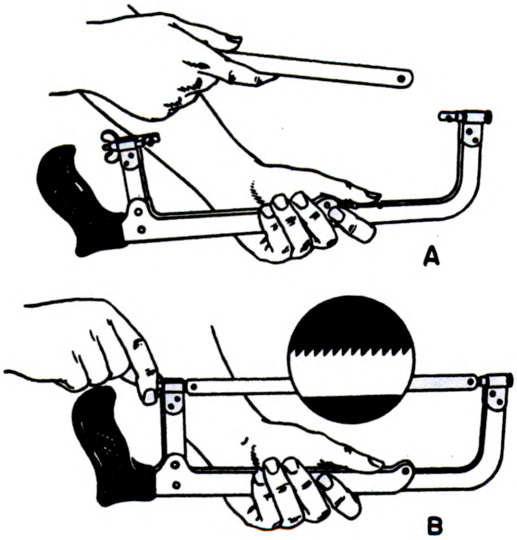


29.9M

Figure 10-12.—Types of points on metal cutting chisels.

of the blade point forward so the hacksaw cuts on the push stroke. Refer to figure 10-13.

The proper technique for holding the hacksaw is shown in figure 10-14. Note that the index finger of the right hand (on the handle) points forward. This aids in guiding the frame. When you begin to cut, let your body sway forward and backward with each stroke. Apply pressure on the forward stroke only and ease up on the back stroke. Long, slow, steady strokes are preferred. To make long, straight cuts near the edge of the work, rotate the blade 90° (figure 10-15). Other useful hacksaw techniques are explained in *Tools and Their Uses*.



44.168

Figure 10-13.—Installing a hacksaw blade in an adjustable frame.

The main danger of a hacksaw is if its blade breaks. Breakage usually occurs if too much pressure is applied on the cutting (forward) stroke. Twisting the saw blade also can result in breakage. Cut straight and slow to avoid any twisting action. Ensure the blade is tight in the frame and that the work is securely fastened in place. If a hacksaw blade is dull, replace it. Do not save old hacksaw blades.

Files are available in a variety of types and sizes. Figure 10-16 provides general information on files and *Tools and Their Uses* explains their purposes. The basic filing technique is similar to the one for using a hacksaw. Use two hands to hold the file and apply slow, full-length, steady strokes to the work. Put pressure on the forward stroke and ease up on the back stroke. Don't use the file in a sawing motion. This damages the tool and the work.

Protect the teeth of a file. Break a new file in carefully by first using it on a soft metal (e.g., brass, bronze). Don't let a file rust or get oily. Oil causes a file to slide across the work and prevents fast, clean cutting. Wrap the file in paper or cloth to protect its teeth when the tool is not in use.

The most important point about files is to keep their teeth clean. Metal filings will accumulate in the teeth and reduce the tool's effectiveness. The

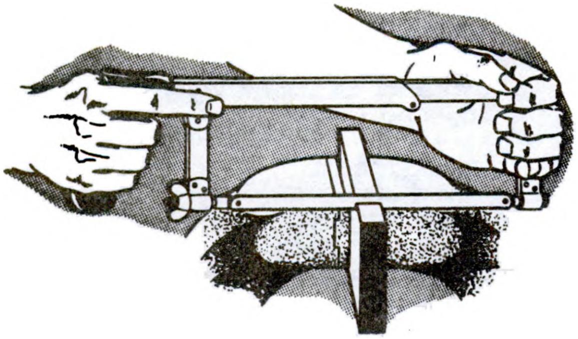


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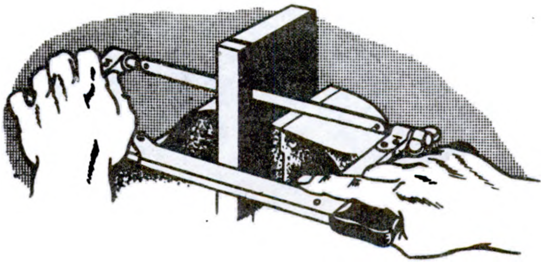
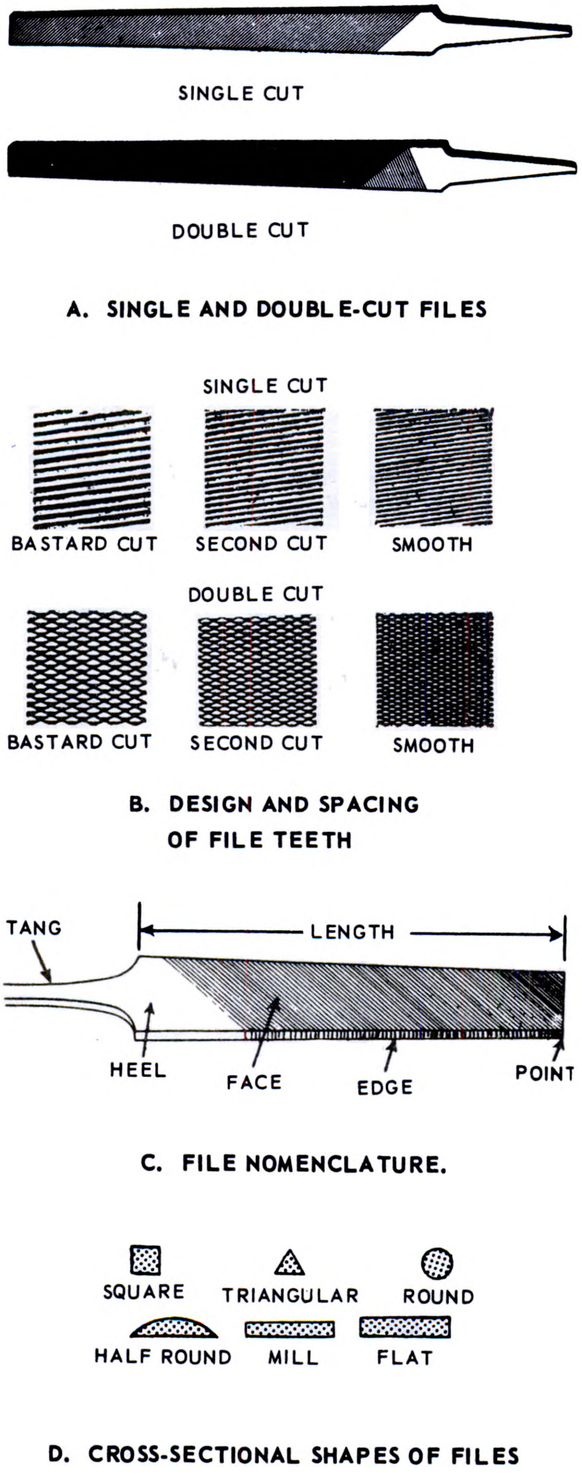
Figure 10-14.—Proper way to hold a hacksaw.



44.169

Figure 10-15.—Making a long cut near the edge of stock.



1.20(44B)A

Figure 10-16.—File information.

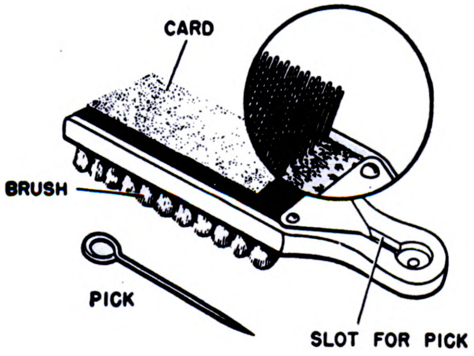
best way to clean a file is to use a file cleaner or file card (figure 10-17). A file card has fine wire bristles made specifically for cleaning between file teeth. Hold the file card parallel to the file and use a pulling motion to clean the tool. Do not hit the file against any object to clean it. The file body is hard but extremely brittle and will snap in two if subjected to sharp blows.

Never use a file for prying or pounding. The body can break and the tang, which is soft, can bend easily. A tight-fitting wood handle should be installed over the tang. This not only makes the tool easier to use but protects your hand from serious injury.

Punches

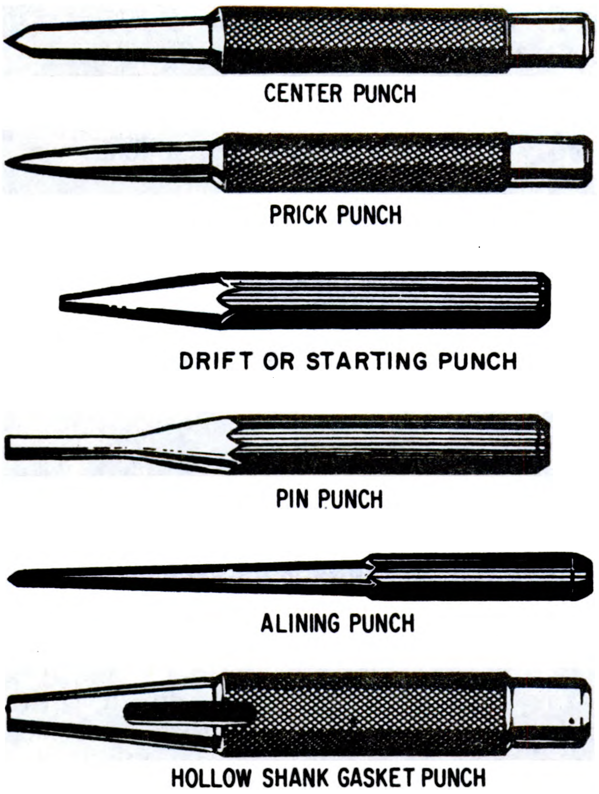
A punch is a tool held in the hand and struck on one end with a hammer. There are several kinds of punches designed to do various jobs. (See figure 10-18.) The center punch is used for marking the center of a hole to be drilled. Drift punches have a long taper from their tip to the body and are made to withstand heavy blows. Pin punches have slim shanks with flat ends or points and are made for lighter blows. Pin punches are quite useful for driving dowel or split pins into or out of small holes.

When you hit a punch, you do not want it to slip sideways over the work. You also do not want the hammer to glance off the punch and hit your



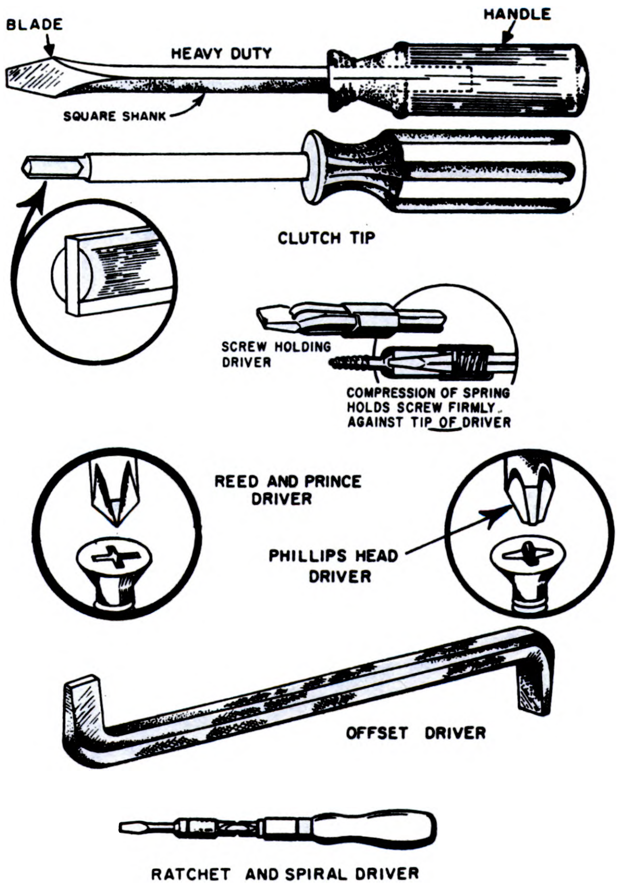
44.11

Figure 10-17.—File cleaner or card.



1.18(44B)

Figure 10-18.—Punches.



1.14(44B)A

Figure 10-19.—Screwdrivers.

(ouch) fingers. Both of these troubles can be avoided if you take the following precautions. First, hold the punch at right angles to the work. Second, hit the punch squarely with the hammer.

Screwdrivers

A screwdriver is a basic handtool. It may be THE most abused item in any toolbox. Screwdrivers are designed for one specific purpose—to turn screws. Screwdrivers are NOT to be used as pry bars, scrapers, chisels, punches, and so on. Common types of screwdrivers are illustrated in figure 10-19.

Screwdrivers have three main parts—handle, shank, and blade. When using a screwdriver, select the proper blade size so the tip fits the screw slot properly. This prevents burring the slot and the blade tip. It also reduces the force necessary to hold the tool on the work. Keep the shank perpendicular to the screw head while you turn the screwdriver.

A screwdriver is another simple tool that can be quite dangerous if used carelessly. One important rule to remember is never get any part of your body in front of the screwdriver blade tip. Consider the tip a sharp object. If the tools slips off the work, serious puncture wounds and equipment damage may result. Ensure the screwdriver's handle is insulated if the tool is used for electrical work. Do not use a wrench or pair of pliers to "help" turn a screwdriver. This extra leverage overtaxes the screwdriver and, generally, ruins the screw slot.

Pliers

Pliers are made in many different styles and shapes. Figure 10-20 illustrates a few popular designs. Pliers are very handy tools and can be used to perform various operations. Combination pliers are used for holding and bending flat or round stock. Long-nosed pliers are commonly called needle-nose pliers. They are especially useful for holding small objects in tight places and for making delicate adjustments. The round nosed kind are handy when you need to crimp thin sheet metal or form a loop in a wire. Diagonal cutting pliers, commonly called "diagonals" or "dikes," are designed for cutting wire and cotter pins close to a flat surface. These pliers are especially useful in the electronic and electrical fields.

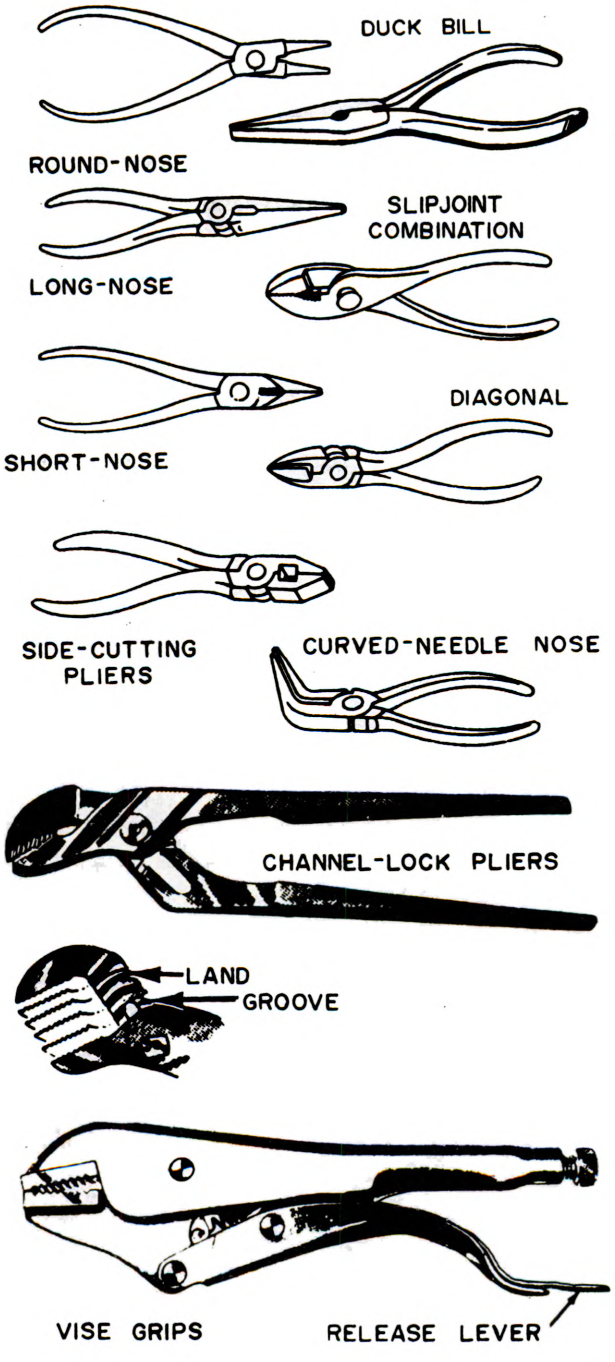


Figure 10-20.—Pliers.

Channel-lock pliers are easily identified by their extra long handles. This leverage makes them a very powerful gripping tool. Vice-grips are adjustable and can be used for holding objects of various shapes. The jaws of vise-grips may have standard serrations or may have a smooth clamp-type jaw. Vise-grips can be clamped and locked in position on the work. This advantage will leave your hands free for other activities.

Pliers must be used properly to be effective. Do not make pliers work beyond their capacity. If you need a powerful force, use channel-locks or vise-grips instead of delicate needle-nose pliers. Do not use pliers to turn nuts/bolts. The serrated jaws of pliers will ruin or round the flats of these fasteners. Cutting pliers (dikes) are designed to cut, not grip.

Nonsparking Tools

When working in an explosive environment, such as in a magazine, take care to avoid producing sparks. Special nonsparking tools must be used in these areas instead of the regular basic handtools. Nonsparking tools are made from a nonferrous (not containing iron) material. Although different metals/alloys are available, brass and bronze are two popular materials. Take care to prevent breaking or distorting these soft metal tools.

Measuring Tools

In ordnance work, you have many reasons to make measurements. Interlock switches must be set or adjusted so they activate/deactivate within specific parameters. The switch adjustment requires a measurement. If you must have a part manufactured, technical drawings will specify the required dimensions. Measurements must be made to ensure the dimensions are within designed tolerances. Some measurements can be "rough"; others must be exact.

Where accuracy is not critical, the common rule (ruler) or a tape measure can be used. However, the majority of ordnance measurements must be very accurate. You have to be conscientious in making these kinds of measurements. Accuracy depends on your ability to use various measuring tools correctly.

Tools and Their Uses describes the typical measuring tools used in the Navy. We will limit our discussion to two devices—a thickness gage and a micrometer. When used properly, these tools can provide exact measurements to within .001 of an inch (or less) of accuracy.

THICKNESS GAGE.—Thickness gages are commonly referred to as feeler gages. Figure 10-21 illustrates a blade-type feeler gage, but there are other shapes and sizes available. Feeler gages are used to check and measure small openings such as point clearances, narrow slots, and so on.

Each blade in a multiple blade feeler gage is a specific number of thousandths of an inch thick. This enables one tool to make several thickness measurements. Most blades are straight, as seen in the figure. Other gages can have short and/or long blades and blades with 45° angles at their end.

To use a feeler gage, insert a blade or combination of blades between the surfaces to be measured. Do so until a snug fit is obtained. The thickness of an individual blade, or the sum of all the blades used, is the measurement between the surfaces. If more than one blade is used, a little math is required. Simply total the thickness numbers of each blade.

Always handle the blades of a feeler gage carefully. Some blades are VERY thin and can be bent, kinked, or torn quite easily. Do not force the blades into openings; start small and work up to the correct thickness. To get an accurate measurement, be sure the blades and the surfaces to be measured are clean. When not in use, the blades of the feeler gage must be closed and protected.

MICROMETER.—Micrometers, commonly called "mikes," are precision tools. They are used to measure distances to the nearest one-thousandth of an inch, which is normally expressed in decimal form. Figure 10-22 shows an outside micrometer caliper and identifies its parts. *Tools and Their Uses* explains other types of micrometers such as the screw thread, inside, and depth micrometers.

The frames of micrometers are available in a variety of sizes. The most common type is made so that the longest movement possible between the spindle and anvil is 1 inch. This movement is the "range" of the mike and indicates the size of the largest work it will measure. Do not force a mike to measure more than it is capable or the tool can be ruined.

Reading a Micrometer.—The key to using a micrometer is knowing how to read it properly. In figure 10-23, we have enlarged the spindle and thimble scales of a 1-inch mike. To understand these scales, you need to know that the threaded section on the spindle has 40 threads per inch. Therefore, every time the thimble completes one

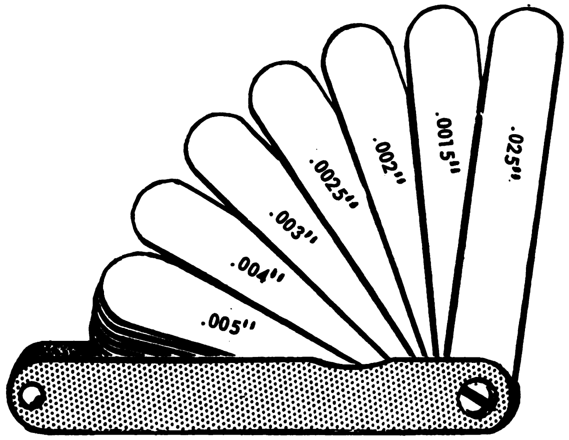


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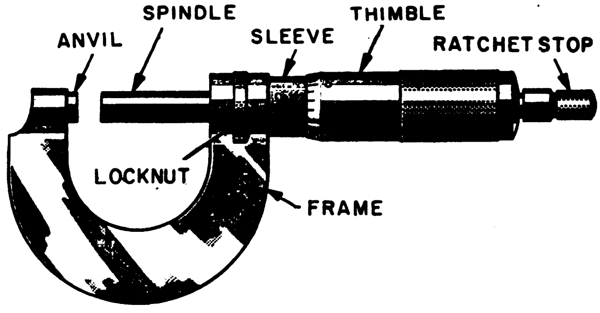
Figure 10-21.—Thickness of feeler gage.



4.20.1A

Figure 10-22.—Nomenclature of an outside micrometer caliper.

revolution, the spindle advances or recedes 1/40″ (0.025″).

Notice that the horizontal line on the stationary sleeve scale is divided into 40 equal parts per inch. Every fourth graduation is numbered 1, 2, 3, 4, etc. These graduations represent 0.100″, 0.200″, and so forth. When you turn the thimble so that its edge is over the first sleeve line past the 0 on the thimble scale, the spindle has opened 0.025″. If you turn the spindle to the second mark, it has moved 0.025″ plus 0.025″ or 0.050″.

You use the scale on the thimble to complete your reading when the edge of the thimble stops between graduated lines. This particular scale is divided into 25 equal parts, each part representing 1/25 of a turn; 1/25 of 0.025″ is 0.001″. As you can see, every fifth line on the thimble scale is marked 5, 10, 15, etc. The thimble scale, therefore, permits you to take very accurate readings to the thousandth of an inch. Fairly accurate readings (to the ten thousandth of an inch) are possible if you estimate (interpolate) the distance between the divisions on the thimble scale.

The closeup in figure 10-24 will help you understand how to take a complete micrometer

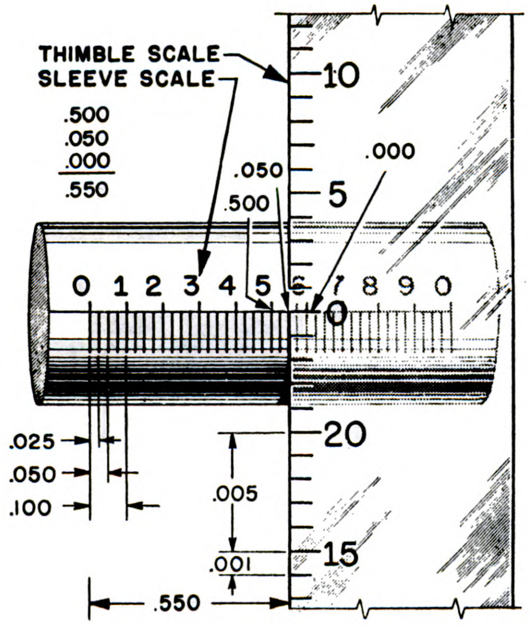


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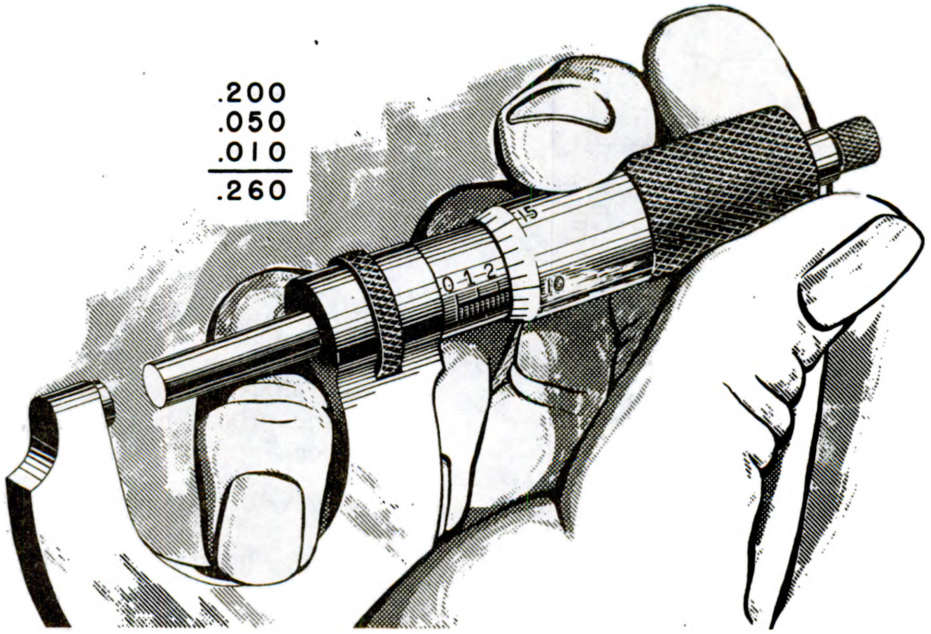
Figure 10-23.—Sleeve and thimble scales of a micrometer (enlarged).

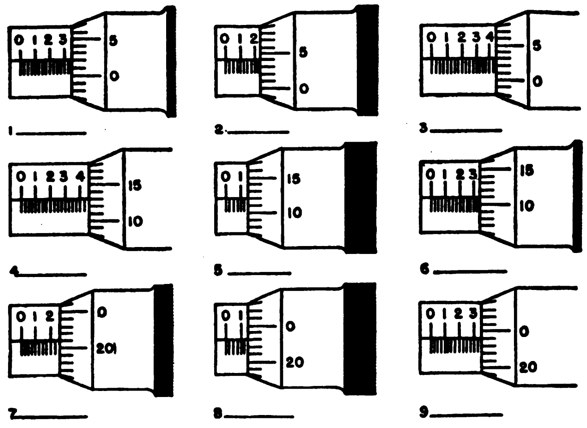


4.20.2

Figure 10-24.—Reading a micrometer caliper.

reading. Count the units on the thimble scale. Then add them to the reading on the sleeve scale. The reading in the figure shows a sleeve reading of 0.250" with the 10th line on the thimble scale coinciding with the horizontal sleeve line. (The thimble has stopped slightly more than halfway between the number 2 and 3 graduations on the sleeve scale.) The number 10 on the thimble scale means the spindle has moved away from the anvil an additional 10 × 0.001" or 0.010". Add this amount to the 0.250" sleeve reading. The total distance is, therefore, 0.260". Refer to figure 10-25 to get more practice reading a micrometer. The correct readings are given following the figure.

In figure 10-25, the thimble graduations have been "conveniently" stopped exactly on the spindle's horizontal line. What happens when the horizontal line falls between two thimble graduations? Essentially, we can obtain a more accurate reading through the process of interpolating. Interpolation is best defined as an "educated guess"! Refer to figure 10-26. The horizontal line has stopped between two thimble graduations and is closer to the 15 than the 14.

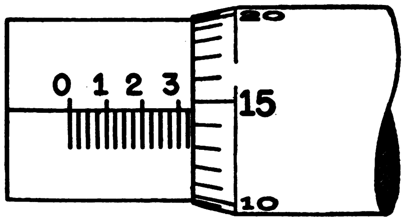


Answers for checking—

1. = 0.327
2. = 0.229
3. = 0.428
4. = 0.438
5. = 0.137
6. = 0.336
7. = 0.246
8. = 0.148
9. = 0.349

4.20

Figure 10-25.—Micrometer reading exercises.



A
.300
.025
.015
.340

B
.300
.025
.014
.0007
.3397

29.266F

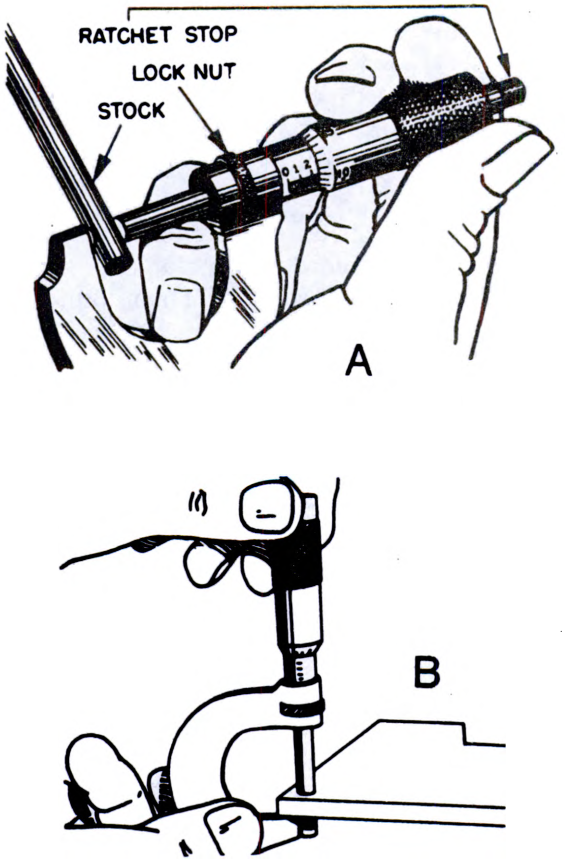
Figure 10-26.—Interpolating a micrometer reading.

Calculation A in figure 10-26 shows the reading rounded off to the nearest three decimal places. Calculation B illustrates a more accurate reading to four decimal places. Estimate the number of tenths between the thimble graduations (14 and 15). Each tenth equals one ten-thousandth (0.0001) of an inch and, in this example, is stated as 0.0007. In actual practice, take a few readings (and interpolations) to determine a good average and accurate reading.

There are more accurate micrometer calipers available that will eliminate most of this interpolation. However, they will not be discussed in this text.

Using the Micrometer.—The outside micrometer is useful in measuring the diameter of round stock or the thickness of a flat surface. The basic procedures are similar, but minor differences in technique exist.

View A of figure 10-27 demonstrates how to measure a small piece of round stock. Hold the stock in one hand and the mike in the other as shown. In this manner, the frame is supported and the work is easily guided over the anvil. The thumb and forefinger are in position to turn either the thimble or ratchet stop.



4.20.2A(1C)

Figure 10-27.—View A—measuring round stock; View B—measuring flat stock.

The spindle can be turned down either by "feel" or by using the ratchet stop. If you turn the spindle directly, your "feel" should be very light. Since the contact area is very small between the stock and the mike's spindle and anvil, only a light pressure is needed. Otherwise, a heavy "feel" will produce an inaccurate reading. Hold the mike lightly and for only as long as necessary. Heat from your hand can cause the metal to expand and results in faulty readings. If the stock is small, read the mike before removing it from the work.

View B of figure 10-27 illustrates how to measure flat surfaces. The work should be stationary and well supported. Hold the mike straight so the spindle and anvil contact the surface area evenly. Since the contact area will be greater between the stock and the mike's spindle and anvil, use a heavier "feel" when you turn the spindle directly.

Caring for Micrometers.—As mentioned earlier, micrometers are precision measuring instruments. Therefore, they should be handled carefully and be well-maintained. Micrometers must be kept clean and lightly oiled. Be sure they are placed in a case or protective box when not in use. Anvil faces must be guarded from damage. Do not clean the face of an anvil with an abrasive cloth (e.g., sand paper or emery cloth). Use a soft rag or cloth instead.

POWER TOOLS

Power-driven tools are extremely useful in maintenance work and are commonplace in the ordnance field. These tools make many jobs easier and faster to complete. Our discussion is limited to describing the general and specific safety precautions for portable electric and pneumatic power tools.

Drills, sanders, grinders, saws, impact wrenches, soldering irons/guns, vacuum cleaners, and drop or trouble lights are common portable electric power tools. Air drive motors, chipping hammers, impact wrenches, needle guns, and rotary scalers (deck crawlers) are common portable pneumatic tools. Many of these devices are described in *Tools and Their Uses*.

General Precautions

Safety in the use of any power-driven tool cannot be overemphasized. Listed below are several general precautions that must be observed.

- First, never operate a power tool unless you are thoroughly familiar with its controls and operating procedures. When in doubt, consult the tool's operating manual or ask someone who knows.

- All portable tools should be inspected before use to see that they are clean and in good repair.

- Before a power tool is connected to a source of power, be sure the switch on the tool is in its OFF position.

- See that all electrical cables and air supply hoses are positioned so they do not create tripping hazards.

- When operating a power tool, give it your undivided attention. Do not distract or disturb another individual operating a power tool either.

- Keep all safety guards in position. Use safety (face) shields, goggles, and rubber gloves when required. Fasten all loose shirt sleeves and remove jewelry.

- Never try to clear jammed machinery until you remove the source of power first.

- After using a power tool, turn it OFF and then disconnect it from the power source. Wait for all rotation to stop before cleaning the tool. Remove all waste and scraps from the work area and store the tool in its assigned location.

Electric Power Tool Precautions

Electric power tools are the most convenient to use since electrical outlets are located everywhere aboard ship. However, electric power tools are potentially the most dangerous because of the ever-present shock hazard. Electric shock strikes without warning and is often tragic in its results. When using electric portable power tools, ALWAYS keep the following safety precautions in mind.

- Shipboard conditions are particularly conducive to electric shock possibilities because the body is in contact with the ship's metal structure. Extra care is needed when body resistance may be low because of perspiration or damp clothing. Insulate yourself from ground. Use an approved insulating material to cover any grounded metal with which you might come into contact. A very suitable material is rubber matting. Always report any shock received from electrical equipment. Minor shocks often lead to fatal shocks later on. Do not make repairs to electrical tools unless you are qualified and authorized to do so. Generally, the ship's Electrician's Mates will make all such repairs and ground checks.

- Be sure to use a grounded outlet, a three-conductor power cord, and a three-prong plug.

- If water exists anywhere in the vicinity of the work area, be especially cautious. Dry the area completely before using an electric tool.

- If an extension cord is required, always connect the power cord of a portable electric tool into the extension cord first. Then connect the extension cord into a convenience outlet. Follow the reverse procedure when disconnecting the tool. Unplug the extension cord from the receptacle first. Then disconnect the power cord of the tool from the extension cord. The extension and power cords can each be no longer than 25 feet (or a maximum 50 feet). Extra extension cords should be limited, wherever possible, to maintain allowable resistance to ground.

- Be sure that power cords do not come in contact with sharp objects. The cords should not be allowed to kink. They also should not be allowed to come in contact with oil, grease, hot surfaces, water, or chemicals.

- When power cords are damaged, they should be replaced, not repaired.

- Power cords should be of sufficient length so they are not subjected to longitudinal stresses. Never pull a power cord taut to make a connection.

- Power cords should be checked frequently while in service to detect unusual heating. Any cable which feels more than comfortably warm to the bare hand should be investigated immediately. This indicates the circuit is being overloaded and is a dangerous condition.

- Sparking electric tools should never be used in places where flammable gases, liquids, or explosives are present. Pneumatic tools should be used in these areas.

- Have ample illumination. If drop or trouble lights are required, a light guard must be installed to protect the bulb.

Pneumatic Power Tool Precautions

Portable pneumatic power tools are tools that look much the same as electrical power tools. However, they use the energy of compressed air instead of electricity. Because of the limited number of outlets for compressed air aboard ship, the use of pneumatic power tools is not as widespread as electric tools.

Although the electric shock hazard is eliminated, compressed air has its own dangers. In operating air-driven tools, take the following precautions.

- Inspect the air supply hose for cracks or other defects; replace the hose if it is found defective.

- Before connecting an air supply hose to the compressed air outlet, open the supply control valve momentarily. This action purges, or clears, the supply line of water and other foreign matter. Then make sure the supply hose to the tool is clear. Connect it to the supply outlet and, again, open the supply control valve momentarily.

- If possible, secure the air supply hose by tying it down. Should it break, the hose will flail about and create a serious missile hazard. Along the same lines, ensure all hose couplings are securely fastened and in good shape.

- Stop the flow of air to a pneumatic tool by closing the supply control valve at the compressed air outlet. Do so before adjusting, repairing, or disconnecting a pneumatic tool. After the air supply is secured, run the tool until the compressed air in the air supply hose has bled down to zero pressure. Do not disconnect the tool from its supply hose until all air pressure in the line has been vented to atmosphere.

FASTENING DEVICES

Fastening devices are designed to attach components together securely. Typical fasteners are bolts, machine screws, capscrews, setscrews, turnlock fasteners, rivets, nuts, washers, keys, and pins. Consult *Tools and Their Uses* for a complete description of these devices.

Although the subject of "nuts and bolts" may seem simple, you must be aware of quite a few details about these devices. On the job, you need to know how to identify, select, and use fastening devices properly. One of the more popular fasteners in ordnance work is the machine screw. What is the difference between a "machine screw" and a "bolt"? Although there are some minor technical differences, essentially both terms describe the same device. For our purposes, we will use the shorter term—bolt.

Generally, a bolt is screwed into a hole tapped with matching threads. Bolts also may be used with nuts. A complete description of a bolt must include various factors. Let us consider the following example of a "1 inch, 8-32 NC, hex head, steel, chromium-plated" bolt. The first number identifies the length of the bolt. The next two numbers identify the diameter and pitch (threads per inch) of the bolt. Standard bolt diameters are expressed in gage numbers or fractions of an inch. The "8-32" means that the screw gage is No. 8 (or in decimal equivalent .164″) and there are 32 threads per inch. The number of threads per inch has been standardized by the National Screw Thread Commission into two basic thread series. One is called the National Coarse (NC) Thread Series, while the other is the National Fine (NF) Thread Series. (An extra fine (EF) series exists for certain applications.) Coarse threads are spaced slightly farther apart than fine threads. A comparable No. 8 bolt machined with fine threads would be designated an 8-36 NF and have more threads per inch.

The next identifier in our example describes the bolt head's shape. Hex, short for hexagon, is a very popular head shape. Most bolts are made of steel, but brass, aluminum, and Monel are available. Bolts also may be plated (e.g., chromium-plated) to help prevent corrosion. Monel bolts are highly resistant to the corrosive action of salt water.

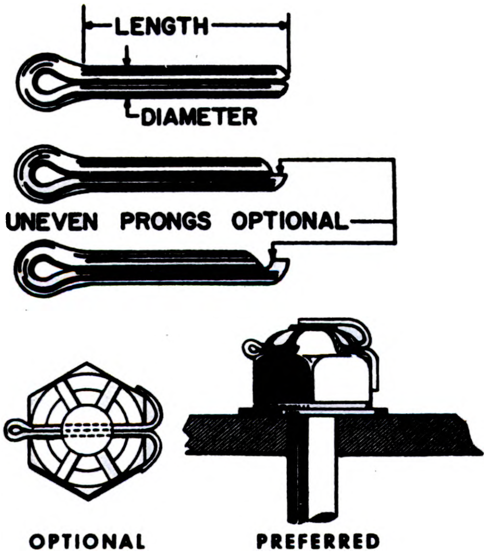
We will now concentrate on another area associated with fastening devices. Our discussion centers around two methods used to secure fasteners so they do not work loose through vibrations. Loose bolts, screws, and nuts can cause very serious problems. Should certain fasteners come completely undone, the safety of the equipment and personnel could be endangered. Various safetying methods exist. The more common and positive means are (1) cotter pins and (2) safety or lock wiring.

Cotter Pins

View A of figure 10-28 illustrates several typical cotter pin shapes. Some pins are made of low-carbon steel, while others are of stainless steel and are more resistant to corrosion.

A cotter pin installation is shown in view B of the figure. The pin should fit neatly into the hole and have very little sideplay. In the preferred installation method, the prong that is bent up and over should not extend beyond the bolt's diameter. The prong bent downward should not touch the washer. If necessary, cut/trim the prongs down to the required size.

In the optional wraparound method, the prongs should not extend outward. They should be bent over a reasonable radius so they contact the sides of the nut. Do not make the bends with sharp angles as the prongs tend to break easily. Needle-nose or diagonal pliers can be used to make the initial bends. A soft face mallet is the best tool to use to put the final bend on the prongs.



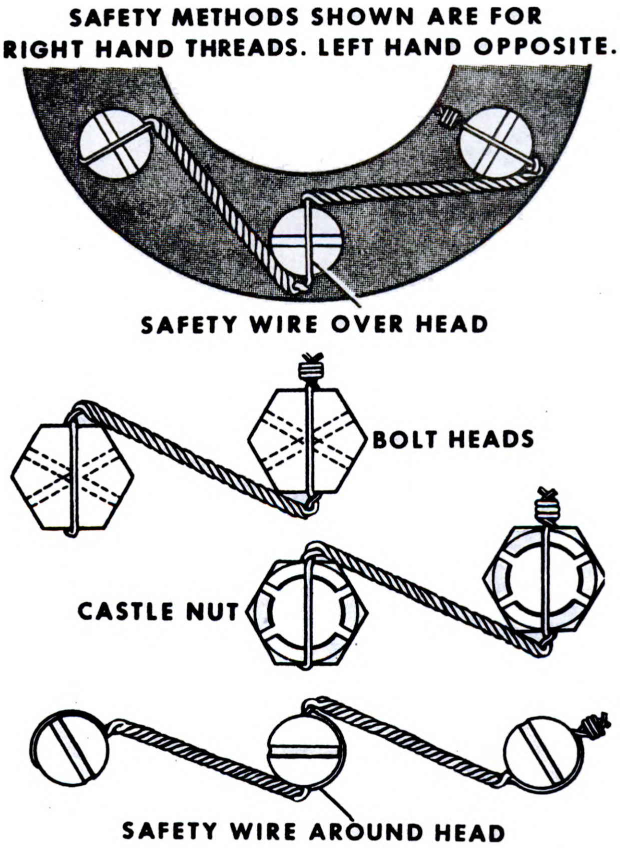
44.65(A-B)

Figure 10-28.—View A—types of cotter pins; View B—cotter pin installations.

Safety Wiring

Safety wiring (commonly known as lock wiring) is the most positive and satisfactory method of securing various fasteners and connectors. The principle of the wiring method is quite simple. Two or more devices are wired together so any tendency of one device to loosen is countered by the tightening of the wire and the other device.

Safety wire is normally made of corrosion-resistant steel, and is available in diameters (or


SAFETY METHODS SHOWN ARE FOR RIGHT HAND THREADS. LEFT HAND OPPOSITE.
SAFETY WIRE OVER HEAD
BOLT HEADS
CASTLE NUT
SAFETY WIRE AROUND HEAD

12.245(44B)A

Figure 10-29.—Safety wiring methods.

sizes) of 0.020 inch to 0.091 inch. The largest diameter wire that the holes in the fasteners will accept should be used. Safety wire is normally available on spools.

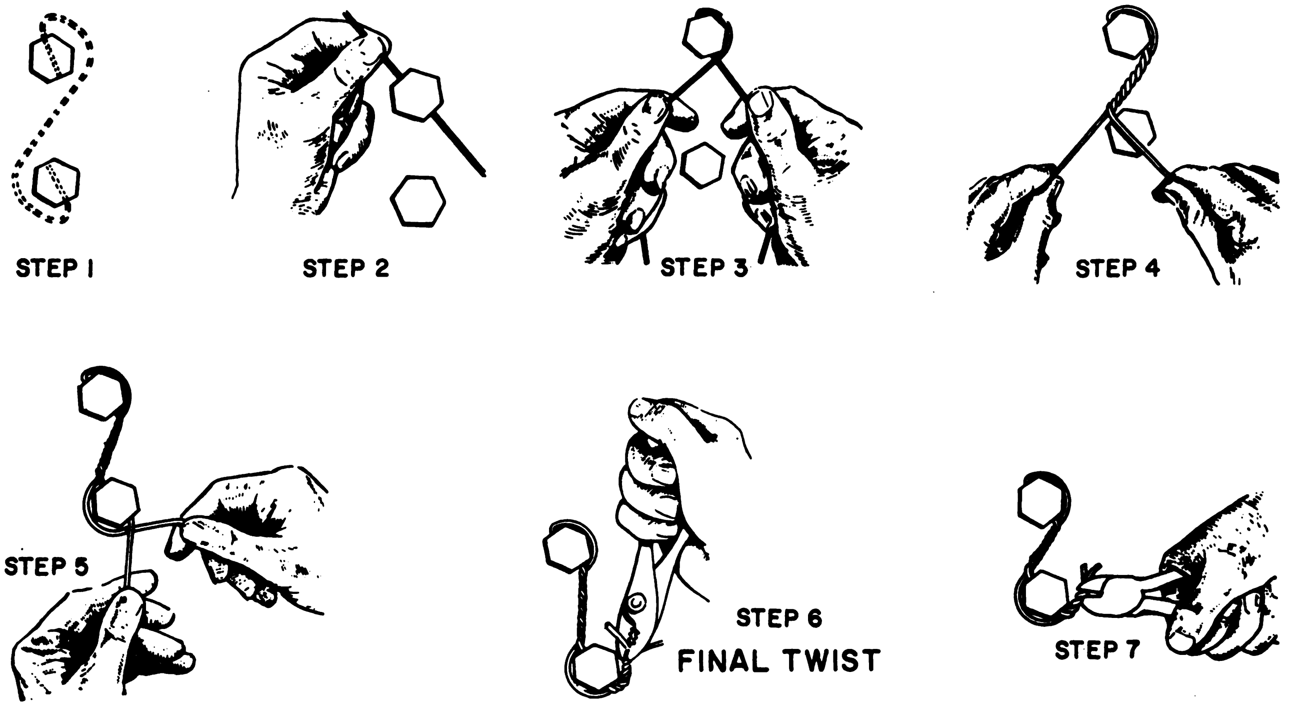
In ordnance work, the double-twist method of safety wiring is recommended. Figure 10-29 illustrates various styles of this method—wire over head or wire around head. For best effect, no more than three widely spaced fasteners in series should be safety wired using the twist method. Refer to figure 10-30 as the double-twist safety wiring procedure is described.

Step 1—Use this step as your planning phase. Safety wiring is not a simple task and easily can be done wrong. Therefore, think the job through before you start. The phantom lines in the diagram of step 1 represent the directions the safety wire must take for correct locking action. In this manner, all pull exerted by the wire tends to tighten the bolts if they try to loosen.

Step 2—Select the appropriate diameter and length of safety wire and cut it off the spool. Thread it through the upper bolt head until both wire strands are even. With experience, you will be able to judge the "appropriate length" of wire needed for each job. It is better to have too much wire than too little. Excess wire can be cut off later.

Step 3—The technique shown in step 3 is important. The wire coming from the top of the bolt is first drawn (looped) around the side of the bolt head. This wire must be run UNDER the other wire coming from the bottom of the bolt. In this manner, the looped-wire cannot slip up and over the bolt head and cause a slack loop.

Step 4—Step 4 involves twisting the two wires together. There are two ways to do this correctly. The preferred method is to use wire twister pliers. The alternate method is to use your hands as shown in the figure.



12.245(44B)B

Figure 10-30.—Double-twist safety wire installation procedure.

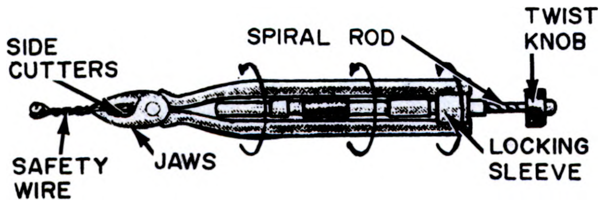
Wire twister pliers (figure 10-31) are designed to hold, twist, and cut safety wire. Using this tool reduces the time required to make a twist and results in a neater job. To operate the pliers, place the two wires between the jaws of the pliers. The wires should be side by side and not crossed. Use your thumb to push the locking sleeve into place. A pull on the twist knob twirls the pliers and makes uniform twists in the wire. The spiral rod may be pushed back into the twister without unlocking it. Another pull on the knob will give a tighter twist to the wire. A squeeze on the handle unlocks the pliers' jaws. The wire can be cut to desired length with the side cutter.

If wire twister pliers are not available, use your hands to twist the wires. Keep the wires parted at about a 60° angle as they are twisted together. Do NOT use any other tool such as vise grips or regular pliers for this phase of the twisting operation. Those tools would damage the safety wire.

Step 5—The technique shown in step 5 of figure 10-30 is important also. Thread the top wire through the bolt head. Loop the bottom wire around the bolt head and ensure it runs UNDER the top wire as illustrated. Again, the looped wire cannot slip up and over the bolt head creating a slack loop.

Step 6—Step 6 shows the final twist. It can be done with wire twister pliers, your hands, or (for the final twist only) regular pliers. A minimum of four twists should be used.

Step 7—Excess wire should be trimmed off with any cutting-type pliers. Bend the remaining twist along the side of the bolt head.



1.21(44B)C

Figure 10-31.—Wire twister pliers.

Experience will improve your safety wiring technique. The following general rules should be observed during safety wiring operations.

- The safety wire must be new for each application.

- All fasteners must be tightened to recommended values before safety wiring is installed.

- All safety wire must be tight and free of kinks after installation. However, it must not be under severe tension. If the wire is too tight, normal handling and vibration will break the wire and render it ineffective.

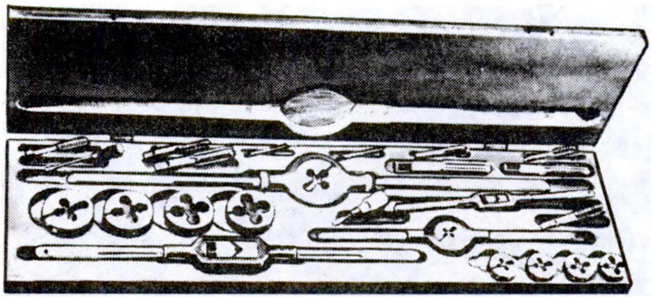
- Ensure installed safety wire will not interfere with moving components.

- Wear approved face and eye protection when handling and trimming safety wire.

TAPS AND DIES

In ordnance work, you will often have the need to make new threads for fasteners. Taps and dies are the tools used to cut threads in metal, plastics, and hard rubber. A tap is used to cut internal (female) threads, while a die is used to cut external (male) threads.

A typical threading set (commonly known as a tap and die set) is shown in figure 10-32.



44.32

Figure 10-32.—A typical tap and die (threading) set.

In addition to a combination of different tap and die sizes, various accessories and operating instructions are provided in each set. Ideally, your work center should have two tap and die sets; one to cut coarse (NC) threads, the other to cut fine (NF) threads. Keep these valuable tools clean and well oiled when not in use.

Our discussion of taps and dies will be very basic. First, we'll describe the tools involved and then explain how they are used. Consult *Tools and Their Uses* for more detailed explanations of this important subject.

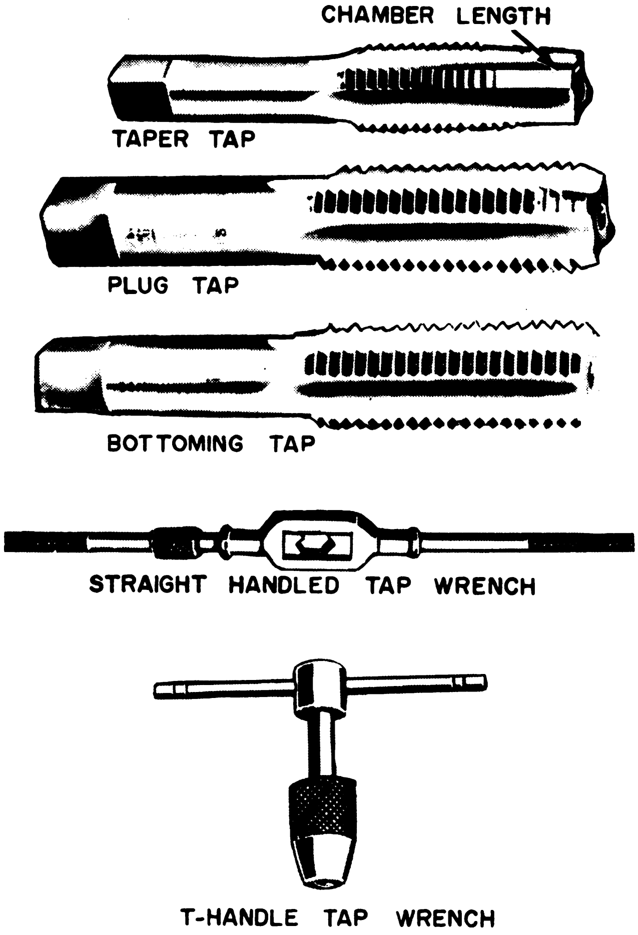
Taps

The most common types of taps for making bolt/machine screw threads are the taper, plug, and bottoming taps (figure 10-33). The taper or starting tap has a chamfer length of 8 to 10 threads. Taper taps are used when starting a tapping operation in a blind hole or when tapping a through (or open) hole. Plug taps have a chamfer length of 3 to 5 threads. Plug taps are used after taper taps. A bottoming tap has a chamfer length of 1 to 1-1/2 threads. Bottoming taps are used to thread the bottom of blind holes and are used after the taper and plug taps have started the way.

Figure 10-33 also shows two common types of tap wrenches. The straight handle tap wrench's jaws can be opened to accept the shanks of the larger taps. The T-handle tap wrench's jaws are very similar to a chuck on an electric drill. This tool is well suited for the smaller taps and delicate work. Do not use regular or socket wrenches to turn taps. A proper tap wrench is designed to hold the tap securely and gives you more control over the work.

Cutting Threads With a Tap

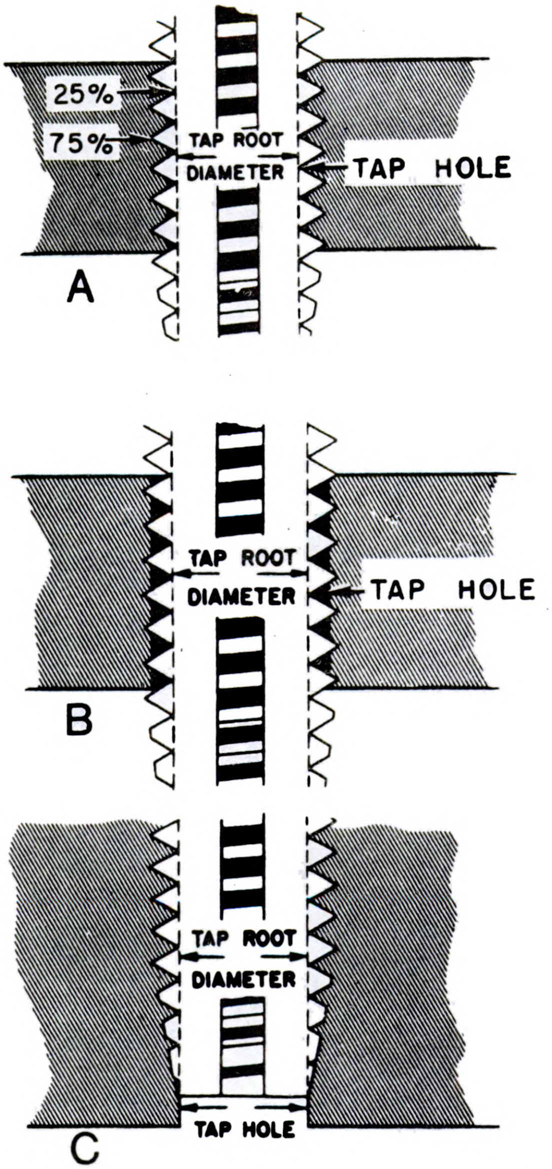
The first step in any tapping operation is to drill a correct size hole (tap hole) into or through the work. When the tap hole is the right size, it is a little larger than the root diameter of the tap (view A of figure 10-34). The tap then cuts a thread which is only 75 percent as deep as the thread on the tap. The other 25 percent of the depth of thread on the tap provides clearance between the tap hole and the root diameter of the tap. If these dimensions/percentages are followed, the tapping operation will be done correctly and easily. If the tap hole is oversize, the tap can only cut shallow threads in the work (view B). With less than a full 75 percent depth of thread, these shallow threads will usually strip. If the tap hole is undersize, there will be no clearance between the tap hole and root diameter of the tap (view C). The tap will turn hard, tear the threads, and probably break.



11.5.1

Figure 10-33.—Taps and tap wrenches.

The best method to determine which drill bit to use for a specific size bolt is quite simple.



44.145

Figure 10-34.—A drilled hole for tapping: A. Proper size; B. Oversize; C. Undersize.

Refer to figure 10-35 and you will see part of a chart. A listing/chart similar to the one in this figure is included with every tap and die set. If you know your bolt's nominal size, read across the chart to find the appropriate drill bit number. For example, to drill and thread a hole for an 8-32 NC bolt, you must use a No. 29 drill bit.

When tapping in steel, use a lubricant. A 50-50 mixture of white lead and lard oil applied with a small brush is preferred. If these materials are not available, a light lubricating oil can be used instead.

To tap a through or open hole, you need only the taper tap. Ensure the tap is aligned straight with the hole and exert an even downward pressure on the tap wrench. First, turn the tap into the hole two quarter turns. Then back it up one quarter turn to break the metal chips. Now turn the tap forward to take up the slack. Continue this sequence—two quarter turns forward, one quarter turn back—until the job is done.

After the first two or three full turns, you no longer have to exert a downward pressure on the tool. You will feel the tap cutting by itself. Don't let metal chips clog the flutes of the tap. The chips can prevent the tap from turning. When the tap won't turn and you notice a springy feeling, stop turning. Back the tap up a quarter turn to break the chips and clean them from the tap's flutes with a wire (figure 10-36). Add some more lubricant and continue tapping. When the threads are cut through an open hole, the tap will turn with no resistance.

To tap a blind hole, you must use all three types of taps—taper, plug, and bottoming. The three views of figure 10-37 show each tap as it drives to the bottom of a hole. You must remove the metal chips from a blind hole or they will interfere with the tapping operation. To do so, the taps must be completely removed from the hole. If possible, turn the work upside down and shake the chips out or use a wire to scrape them out. If the work cannot be turned upside down, carefully use an air hose to blow the chips from the hole. In tapping blind holes, alternate tapping and chip removal operations until each of the three taps reaches the bottom of the hole.

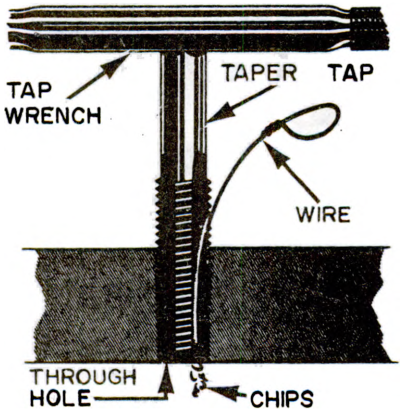
After a tapping job is completed, clean your tools. Brush all metal chips from the teeth of the taps. Give them a good coat of lubricating oil and wipe off the excess. Return them to their proper slot in the tap and die toolbox.

(Thread and Tap Drill Sizes)

Nominal size	Thr'd series	Major diameter, inches	Root diameter, inches	Tap drill to produce approx. 75% full thread	Decimal equivalent of tap drill
0-80	N. F.	.0600	.0438	$\frac{3}{64}$	.0469
1-64	N. C.	.0730	.0527	53	.0595
72	N. F.	.0730	.0550	53	.0595
2-56	N. C.	.0860	.0628	50	.0700
64	N. F.	.0860	.0657	50	.0700
3-48	N. C.	.0990	.0719	47	.0785
56	N. F.	.0990	.0758	45	.0820
4-40	N. C.	.1120	.0795	43	.0890
48	N. F.	.1120	.0849	42	.0935
5-40	N. C.	.1250	.0925	38	.1015
44	N. F.	.1250	.0955	37	.1040
6-32	N. C.	.1380	.0974	36	.1065
40	N. F.	.1380	.1055	33	.1130
8-32	N. C.	.1640	.1234	29	.1360
36	N. F.	.1640	.1279	29	.1360
10-24	N. C.	.1900	.1359	25	.1495
32	N. F.	.1900	.1494	21	.1590
12-24	N. C.	.2160	.1619	16	.1770
28	N. F.	.2160	.1696	14	.1820

44.205

Figure 10-35.—Thread and tap drill sizes; example of cross-reference chart.



44.146A

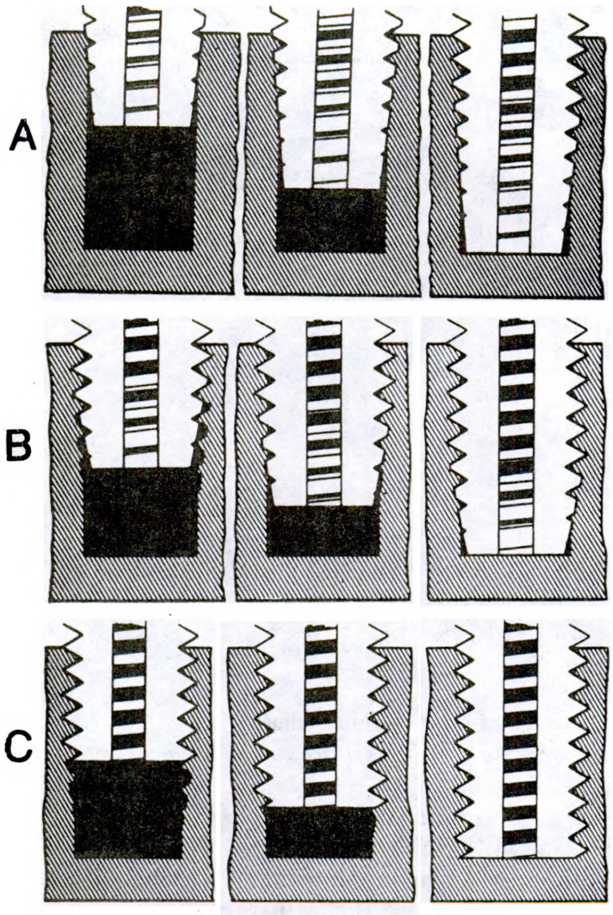
Figure 10-36.—Using a wire to clear metal chips from the flutes of a taper tap in a through hole.

Dies

Dies are used to cut external (male) threads on round stock (rods). There are several different shapes and types of dies available. The coarse and fine tap and die sets in your work center should have a wide range of sizes too. We will describe two types of dies commonly used in ordnance work. They are (1) the adjustable round split die and (2) the plain (or open) round split die. They are often known as "button" dies and can be used in either hand diestocks or machine holders.

The adjustable round split die and a single-screw diestock are shown in figure 10-38. The die has a fine-pitch adjusting screw (designated point A in the figure). Tightening this screw forces the sides of the die apart; loosening this screw allows the sides of the die to spring together. Through this adjustment, we can control the fit of a threaded rod in a tapped hole. For example, by tightening the screw and spreading the die slightly, the threads cut in the rod will be shallow. That will give the rod a tighter fit in the tapped hole. Loosening the adjusting screw results in the die cutting deeper threads. Therefore, the rod will have a looser fit in the tapped hole.

The shallow hole (point B in figure 10-38) is the die's drive hole. It is engaged by a small pin

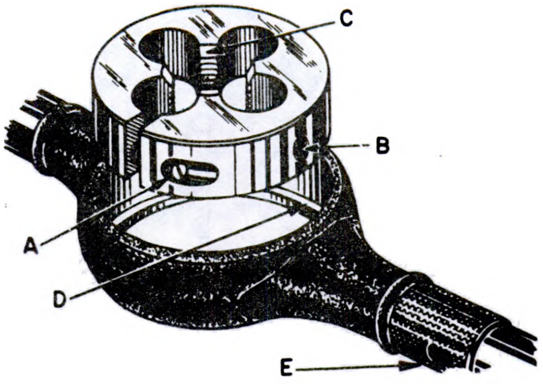


44.146B

Figure 10-37.—Tapping a blind hole: A. Taper tap operation; B. Plug tap operation; C. Bottoming tap operation.

(or screw) that is turned by the diestock's adjustable handle (point E). In this manner, the die is locked in place and cannot rotate or slip within the diestock. When the adjustable handle is tightened, it holds the split die against its adjusting screw. That action maintains the die's setting during a cutting operation.

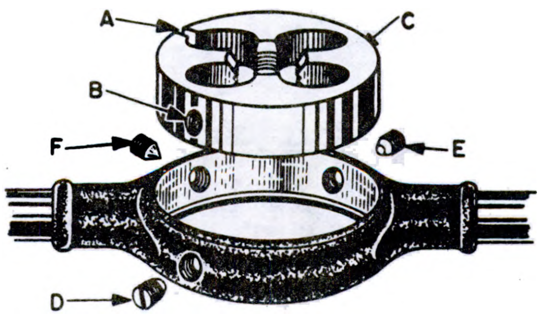
The die's threads, or cutting teeth, are chamfered on one side of the die and unchamfered on the other. The chamfered teeth (point C) help start the die squarely on the round stock. The die is placed into the diestock with its unchamfered teeth against the stock's shoulder (point D).



A—ADJUSTING SCREW
B—DRIVE HOLE
C—CAMFERED CUTTING TEETH
D—SHOULDER
E—DIE STOCK HANDLE

11.5.4A

Figure 10-38.—An adjustable round split die and a single-screw diestock; nomenclature.



A—SPLIT
B—HOLDING SETSCREW HOLE
C—HOLDING SETSCREW HOLE
D—HOLDING SETSCREW
E—HOLDING SETSCREW
F—ADJUSTING SETSCREW

11.5.4B

Figure 10-39.—A plain round split die and a three-screw diestock; nomenclature.

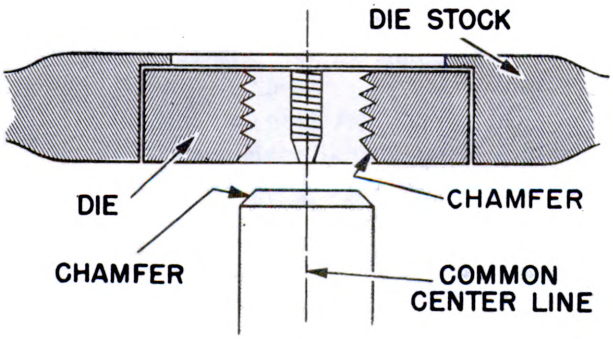
Figure 10-39 illustrates a plain (or open) round split die and a three-screw diestock. A plain round split die does not have an individual adjusting screw to expand or contract its split (point A). There are two shallow holes (points B and C) on either side of the split. They are engaged by the two holding setscrews (points D and E) which lock/hold the die in place. The two holding setscrews have flat points and are tightened after the die's adjustment is made. The adjusting screw is part of the diestock (point F). It has a pointed tip and enters the split (point A) of the die. Tightening and loosening the diestock's adjusting screw spreads and closes the die to control the depth of the threads.

Cutting Threads With a Die

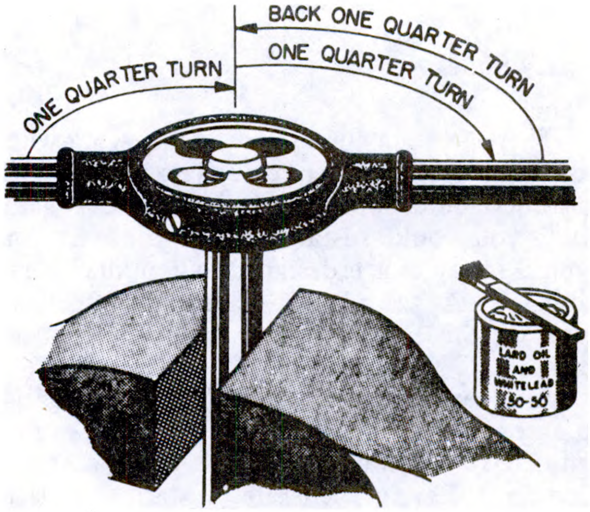
Figure 10-40 shows the relationship between a die and a rod to be threaded. Note that the end of the rod has a slight chamfer or taper. This chamfer, plus the chamfer of the die's teeth, will help start the threads square with the common center line. Use a file to put the slight chamfer on the rod if it has a straight edge.

To begin cutting operations, put some 50-50 white lead and lard oil (or lubricating oil) on the rod. Start the die square with the work. Hold the diestock with two hands and apply a downward pressure. Turn the die clockwise a few full turns until you feel the threads starting to cut. (Refer to figure 10-41.)

After the die starts to cut, rotate it two quarter turns. Then back it off one quarter turn to break the metal chips. Repeat this process as the cutting operation continues. When you have cut enough threads so the rod comes through the back of the die, stop cutting operations. Remove the die and test-fit the rod in its tapped hole. You do this to check the adjustment of the die.



44.149
Figure 10-40.—Position of diestock in relation to the chamfer on the end of the rod.



11.5.4C
Figure 10-41.—Cutting external threads on round stock.

Adjusting a die to produce a thread of proper fit is a trial-and-error procedure. If the fit is too loose, cut off and discard the portion of the rod you just threaded. Then, expand the die by tightening the adjusting screw (or pointed setscrew). The die will spread, cut shallower threads on the rod, and produce a tighter fit.

If the fit is too tight, it is not necessary to cut off the end of the rod as before. Adjust the die by loosening the adjusting screw (or pointed setscrew). That causes the die to contract and results in a deeper thread cut. Run the die down the threads on the rod. Remove the die and do another test-fit in the tapped hole. The fit should be looser and (if you are lucky) just right.

After thread-cutting operations are completed, clean your tools before putting them away. Brush off all metal chips and give the die and diestock a coat of lubricating oil.

PERSONAL SAFETY EQUIPMENT

Personal safety equipment includes such items as safety shoes, goggles and face shields, gloves, and hard hats. These items are available and issued for your protection. On certain jobs, their use is mandatory. Therefore, be sure to wear them when required.

Safety Shoes

There are many times in ordnance work when you must deal with heavy objects. Should such an object be dropped onto or rolled over your foot, you could sustain serious injuries. The typical safety shoe is designed to limit damage to your toes. A steel plate is placed in the forward area of the shoe so your toes will not be crushed.

Another type of safety shoe is designed for use in an explosives area. Metallic nails and eyelets may strike a metal surface and cause a spark. Certain soles can generate a static electrical charge. Following the nonsparking-tool principle, these items are eliminated from this kind of safety shoe to reduce the potential of an accidental explosion.

Goggles and Face Shields

Proper eye protection is of the utmost importance. Eye protection is necessary because of the real dangers from flying objects striking the eyes. These hazards are ever present during all welding, cutting, grinding, chipping, and similar operations. Therefore, it is mandatory that you always use appropriate eye protection equipment.

There are many types of goggles and face shields available. Certain goggles have plastic windows which resist shattering upon impact. Others are designed to limit the harmful infrared and ultraviolet radiation from welding arcs or flames by using filtered lenses. Eye protection must be worn when you are using any type of power tool. Eye and face protection also must be worn when you deal with caustic substances or acids.

Goggles and face shields do NOT eliminate eye hazards. They offer your eyes some degree of protection, so use them always.

Gloves

Use gloves whenever you must handle rough, scaly, or splintery objects. Personnel working with electricity or using portable electric power tools are required to wear insulating rubber gloves. Cloth gloves should not be worn around rotating machinery as the danger of getting caught is possible. Be sure to follow all established regulations concerning the use of gloves.

Hard Hats

Protective helmets (commonly known as hard hats) come in various shapes and colors. Generally, they are made of a tough polyethylene or polycarbonate material. When a falling object strikes the hat, its shock-absorbing capabilities minimize injury to one's head. Yes, your "bell" may be rung, but that is less dangerous than a fractured skull.

There are certain work environments where you must wear a hard hat. At an industrial activity, such as a shipyard, wearing a hard hat is mandatory. Anytime you work with a crane, such as during a replenishment operation, you should wear a hard hat also.

TOOLS—CONCLUSION

Regrettably, we must conclude our discussion of tools at this time and move on to another area. Again, we strongly recommend that you refer to *Tools and Their Uses* for additional information on this important subject.

ELECTRICAL SYSTEM MAINTENANCE

A major part of any GMLS maintenance program involves the servicing of the equipment's electrical system. Most of this care and upkeep is done through routine visual inspections and cleaning operations. Exact instructions for these tasks are outlined on the PMS MRCs.

Before you begin maintenance work on electrical circuits/components, remember one thing—SAFETY. Obey all electrical safety precautions, as they may save your life or the lives of your shipmates. Safety precautions will be listed on the MRCs and are contained in the Safety Summary of the equipment's OP. Be sure you comply with electrical tag-out procedures also. An example of a DANGER tag is shown in figure 10-42. Tag-out procedures are explained in OPNAVINST 3120.22, *Standard Organization and Regulations of the U.S. Navy.*

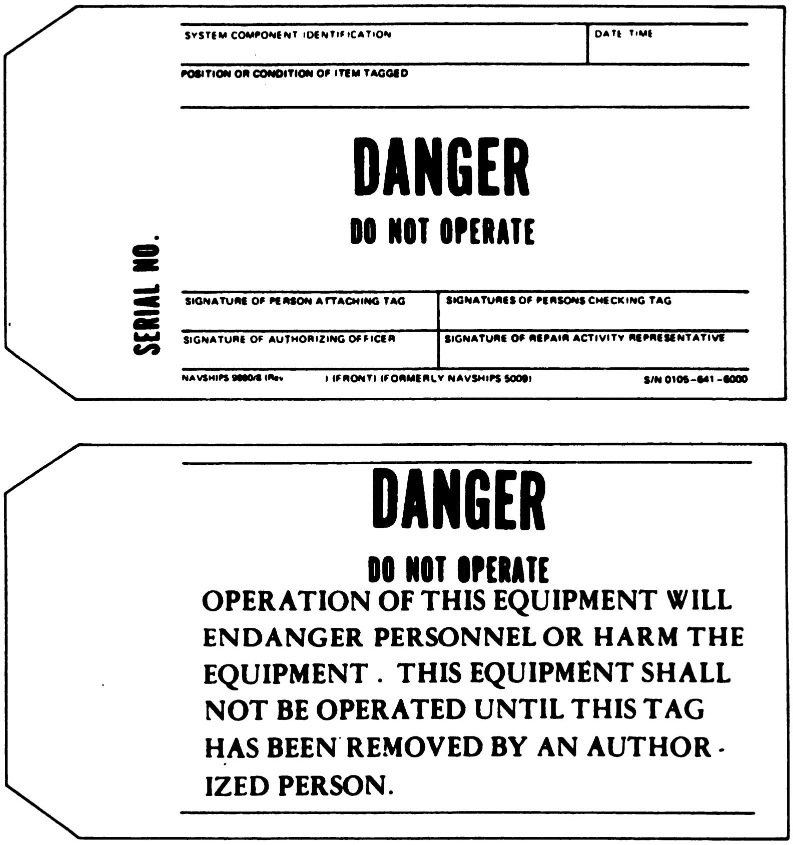
VISUAL INSPECTIONS

All electrical connection boxes, panels, and cabinets throughout a GMLS must be inspected periodically. Generally, the location of the equipment determines the frequency of the check. Panels and cabinets located in interior spaces (e.g., control rooms, missile houses, and magazines) are not exposed to a harsh environment. These areas are climate-controlled and are kept "spotlessly" clean. Therefore, inspections of these equipments can be limited to a semiannual or annual requirement.

However, many electrical connection boxes, switches, solenoids, transformers, and so forth are located in launcher guide arms and carriage structures. These components are more susceptible to damage from the elements. Temperature fluctuations, rain, and heat buildup generated from nearby operating equipments often affect the integrity of such components. Therefore, inspection intervals on these equipments must be more frequent. Quarterly, monthly, and (in some cases) weekly checks are required.

When you hold a visual inspection, look for the conditions listed below.

1. Loose electrical connections
2. Bent or broken terminal lugs
3. Cracked or deteriorated insulation
4. Evidence of overheating, charring, or burning
5. Evidence of moisture



SYSTEM COMPONENT IDENTIFICATION

DATE TIME

POSITION OR CONDITION OF ITEM TAGGED

DANGER

DO NOT OPERATE

SERIAL NO.

SIGNATURE OF PERSON ATTACHING TAG

SIGNATURES OF PERSONS CHECKING TAG

SIGNATURE OF AUTHORIZING OFFICER

SIGNATURE OF REPAIR ACTIVITY REPRESENTATIVE

NAVSHIPS 9890/8 (Rev) (FRONT) (FORMERLY NAVSHIPS 5009) S/N 0105-641-6000

DANGER

DO NOT OPERATE

OPERATION OF THIS EQUIPMENT WILL ENDANGER PERSONNEL OR HARM THE EQUIPMENT. THIS EQUIPMENT SHALL NOT BE OPERATED UNTIL THIS TAG HAS BEEN REMOVED BY AN AUTHORIZED PERSON.

Figure 10-42.—A DANGER tag.

6. Evidence of salt or fungus
7. Improperly mounted terminal boards and cable straps
8. Improperly mounted components
9. Improperly run (treed) leads
10. Improperly mounted or deteriorated gaskets

Visual inspections often reveal discrepancies that can be corrected with minimum labor and parts. Such discrepancies, if left uncorrected, usually turn into major maintenance problems. It is a very good habit to correct the little problems now before they turn into nightmares later.

CLEANING PRACTICES

All electrical connection boxes, panels, and cabinets throughout a GMLS must be cleaned periodically. Cleaning maintenance actions are intended to protect the equipment from the effects of dust, dirt, moisture, and so forth. Instructions for cleaning a particular box, panel, or component are normally given on the same MRC that covers the visual inspection procedures. In short, first you inspect and then you clean. Follow the MRC instructions carefully.

Loose dust, dirt, and lint inside electrical equipment can best be removed with a vacuum cleaner. Clean, dry rags/cloths can be used for general wiping, while a soft brush is good for those hard-to-reach places. Low-pressure air can be used in certain cleaning operations, but it is usually not preferred. If low-pressure air is used, be sure it is free of moisture and other foreign particles. The air pressure also must be sufficiently reduced to prevent damage to the equipment.

Many electronic panels/cabinets have a serious dust problem. This is a direct result of the heat generated by the operation of the electronic components. If these components are not cooled, operational reliability can be affected. Most electronic panels use a small fan or blower to circulate air around/within the unit and dissipate the heat. The air drawn into the cabinet is filtered, but the air filters are not 100 percent efficient. Therefore, you can expect to find some dust in electronic units.

The interior of electronic panels/cabinets should be cleaned frequently. A vacuum cleaner with a nonmetallic hose or a soft brush are the best tools to use. Air filters must be cleaned on a regular basis. If they are neglected and become clogged, excessive heat buildup results, which can cause equipment breakdowns. Accumulated dust and dirt are removed by washing the filter with soapy water and rinsing it clean. Do not reinstall the filter until it has dried completely.

Solvents

Oil, grime, and hard deposits of dirt or other foreign matter can be removed with an approved cleaning solvent. Be sure to consult the MRC and use the cleaner specified for the job. Some solvents and cleaning agents will attack electrical insulation and cause it to deteriorate. Also, be aware that most of these substances are flammable and present a suffocation hazard. Do not use them on or near energized equipment and provide adequate ventilation in the work area.

A typical cleaning procedure calls for slightly dampening a clean, lint-free cloth with the solvent. Lightly rub the surface to be cleaned and then wipe it dry. Repeat the process if required. Complete the job by applying an approved corrosion-preventive compound using MRC instructions.

Moisture

Moisture presents the biggest maintenance trouble for shipboard electrical equipment. Moisture can be in the form of condensation. Variations in temperature cause air to be breathed through any opening or vent in the equipment. As the outside temperature rises, air inside an equipment expands and is partly expelled. As the outside temperature falls, air inside an equipment contracts and outside air is drawn into the gear. During the expansion and contraction processes, condensation or sweating takes place.

Moisture also can be in the form of fresh water (rain), salt water (spray), or oil (from hydraulic leaks). These forms of moisture are the worst kind because they are excellent conductors of electricity. Thus, when a cable or connection box becomes saturated with a liquid, two things happen. First, a current path to the ship's hull is created; this is a ground. Second, especially where dissimilar metals are present, electrolysis and corrosion occur. As a result, electrical connections and wire fittings are slowly eaten away.

The battle against moisture never ends, since it can creep into the smallest of openings. Therefore, when you open a piece of electrical equipment, carefully inspect its cover or door. Check the condition of the sealing gaskets, knife edge, and all fastening devices. If these items are not in good shape, clean them or replace them.

At the same time, inspect the condition of stuffing (or terminal) tubes (figure 10-43). These devices are used to ensure watertight integrity where cables run into connection boxes or panels and through decks or bulkheads. Pipe risers are used to prevent injury to cables where they pass through a deck. Stuffing tubes are then attached to the top of the riser. Ensure the packing in a stuffing tube is in good shape and that the packing ring and nut are tightly secured to keep moisture out.

If moisture is discovered in a connection box, hot-air blowers or electric heat lamps can be used to dry the equipment. Use these devices carefully. Some electrical panels contain built-in heater elements (similar to a space heater). The heater keeps the interior of the unit at a temperature higher than the outside/surrounding air. Some electrical equipments will use a desiccant to combat the moisture problem. The desiccant material is usually silica gel crystals which absorb moisture from the air. Inside the equipment, the desiccant can be distributed in small packages or be placed in special cups or holders.

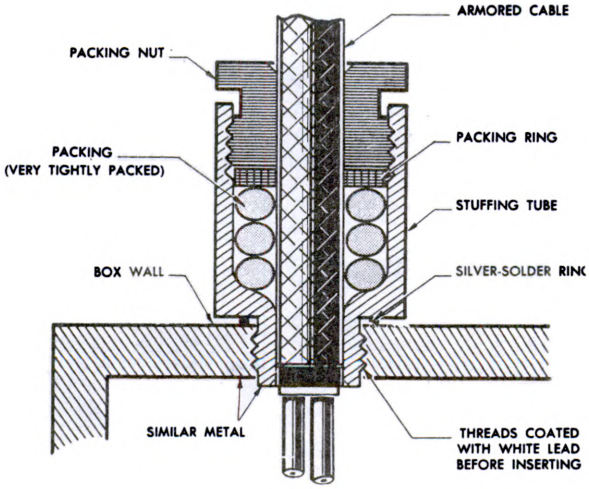


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Figure 10-43.—A cross-section view of a watertight stuffing tube with a cable running through it.

Salt and Fungus

When moisture is present inside electrical equipments, it is not uncommon to find salt and fungus growths. Salt will corrode metals and conduct electricity. Fungus growth will cause decay and rapid deterioration of insulating materials. In both situations, shorts and grounds result.

MRC instructions specify the approved cleaning materials used to remove salt and fungus growths. When using these substances, follow all directions and provide for adequate ventilation.

WIRING TECHNIQUES

The essential element of any electrical system is its cabling or wiring. To keep a system well maintained, you will have to make some minor cabling repairs from time to time. Such work may involve soldering or making splice connections. Terminal connections also must be checked and replaced/repaired when signs of wear or deterioration are evident.

The purpose of the following sections in the text is to review the basic skills of proper wiring techniques. NEETS Module 4 provides a general discussion of these subjects, so be sure to consult it. We will only cover the highlights of that text and present some additional information here.

SOLDERING

Soldering is the process of uniting two or more metals with a fusible alloy. The alloy is called solder and commonly consists of a tin-lead mixture. A 60/40 solder (60% tin and 40% lead) is generally used to solder wires to electrical connectors, splices, and terminal lugs. A 63/37 solder (63% tin and 37% lead) has a lower melting point than 60/40 solder. Therefore, 63/37 solder is preferred for use in PC board and microminiature electronic repairs.

Cleanliness is the most important factor in efficient and effective soldering. Solder will not adhere to dirty, greasy, or oxidized surfaces. Connections to be soldered should be cleaned just before the soldering operation is performed. A mechanical means such as a file or an abrasive cloth can be used. Grease or oil films should be removed with a suitable solvent.

Flux is a cleaning agent used to remove oxidation during the soldering operation. There are two classes of flux—corrosive and noncorrosive. Corrosive fluxes should not be used in electrical work. They will corrode the connection and create a defective joint. Noncorrosive rosin fluxes are preferred materials and are available in paste, liquid, or powder form. A 60/40 rosin-core solder is quite popular in electrical work. During soldering, the boiling flux floats away the oxide film from the work surface. Then, the molten solder quickly fuses to the clean surface to form the bond.

Soldering Tools

Various types of soldering tools can be used to heat the work. Three common tools are the soldering iron, the soldering gun, and the pencil iron. Special tips are available to adapt a particular tool to a variety of jobs.

The important difference in soldering iron sizes (figure 10-44) is not the temperature (they all produce 500°F to 600°F), but the thermal inertia. This is their ability to maintain a satisfactory soldering temperature while giving up heat to the joint to be soldered. Small wattage irons should NOT be used to solder large conductors. They don't generate enough thermal inertia. A well-designed soldering iron is self-regulating because the resistance of its heating element increases with the rising temperature. Thus, the amount of current used is limited to a satisfactory level.

Soldering iron tips will become pitted after continued use. When this occurs, you must file the tip until it is smooth and retin it. (Refer to figure 10-45.) Tinning is the process of putting

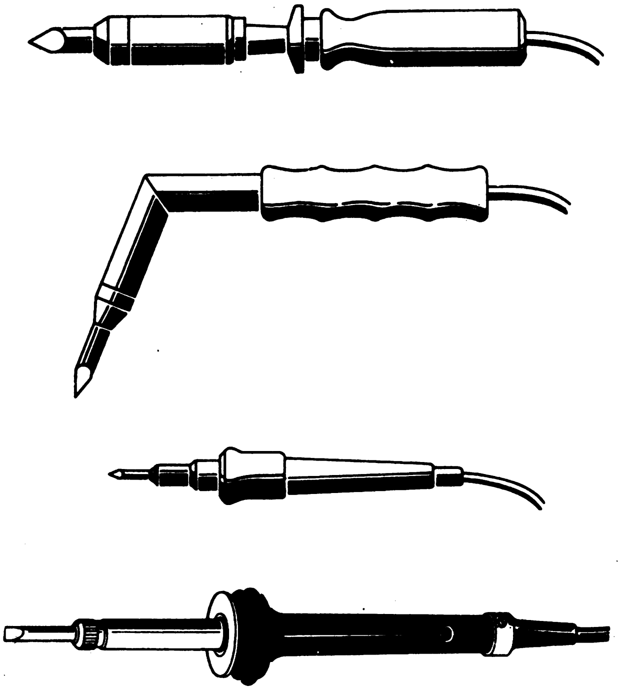
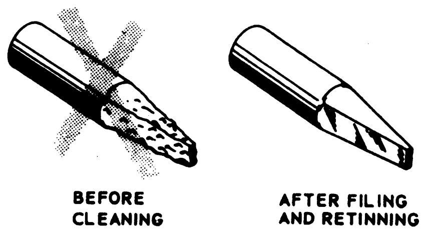
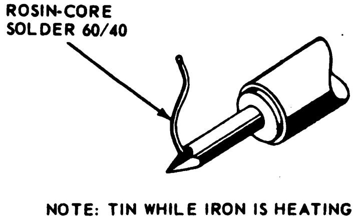


Figure 10-44.—Typical soldering irons.



Soldering Iron Tip Before and After Cleaning



NOTE: TIN WHILE IRON IS HEATING

Tinning Soldering Iron Tip

Figure 10-45.—Reconditioning a pitted soldering iron tip; tinning.

a light coat of solder on the tip. It promotes better heat transfer from the soldering iron's tip to the work and prevents oxidation. It also provides better control of the heat to prevent a solder buildup on the tip.

When a soldering gun (figure 10-46) is used, do not depress the trigger switch for periods longer than 30 seconds. This will cause the tip to overheat to the point of incandescence. The nuts or screws that retain the tips on soldering irons and guns tend to loosen because of the continuous heating and cooling cycles. Those nuts or screws should be tightened periodically. You should NEVER use a soldering gun on electronic components such as resistors, capacitors, or transistors. Soldering tools are rated according to the number of watts they consume. The typical soldering gun is rated between 100 and 250 watts. That is too high and dangerous for electronic soldering.

Pencil-type soldering irons (figure 10-47) are light and easy to use. They also have a wattage rating of less than 40 watts and are recommended for electronic soldering. When you change the screw-in tips of pencil irons, use an ''antiseize'' compound on its threads. The next time you change the tip, it will be easier to remove. If you do not have a suitable tip for a particular job, fashion one. Wrap a length of copper wire around a regular tip and bend it to the proper shape for the purpose (figure 10-48).

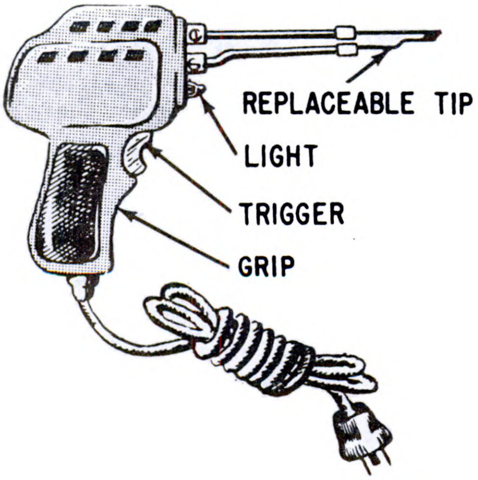


Figure 10-46.—Soldering gun.

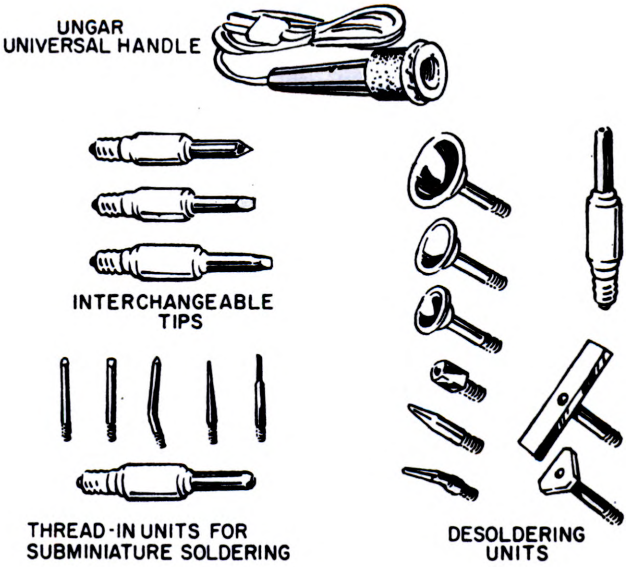


Figure 10-47.—A pencil-type soldering iron with various tips.

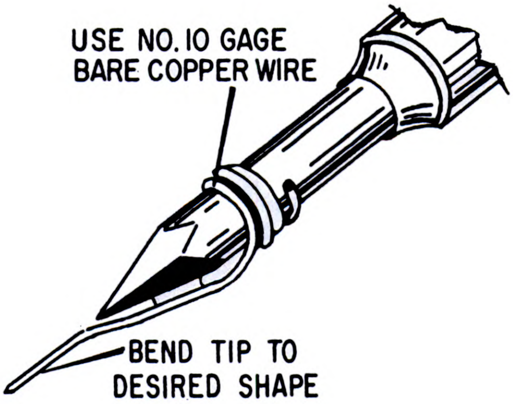


Figure 10-48.—An improvised soldering tip.

One sizzling burn experience is usually enough to breed a healthy respect for a hot soldering tool and hot solder. When using a soldering iron or gun, keep the following safety points in mind. Electric soldering irons must not remain plugged in any longer than necessary. Keep them away from flammable material and always assume that a soldering iron is hot. Never rest a heated iron anywhere but on a metal surface or rack/stand provided for this purpose. Faulty action on your part could result in fire, extensive equipment damage, and serious injuries.

One common misuse of the soldering iron is the improper removal of excess solder from the iron's tip. Avoid striking the iron on a solid object to remove the excess solder. This may damage the heater element. Never swing or whip an iron to remove excess solder either. Bits of solder that fly off may cause serious skin or eye burns or ignite combustible materials in the work area. Use a cloth or damp sponge to clean a hot iron. DO NOT hold the cleaning cloth or damp sponge in your hand. Always place the cloth or damp sponge on a suitable surface and wipe the iron across it to prevent burning your hand.

After using a soldering iron, disconnect its power cord. When the iron has cooled off, store it in its assigned storage area. Do not throw soldering irons into a toolbox. When storing irons for long periods of time, coat the shaft and all metal parts with a corrosion preventive compound.

Soldering Procedures

Many equipment failures can be attributed to poorly soldered joints. Since equipments aboard ship are subjected to continual vibration and frequent shock, all soldering must be done with the utmost care. The following suggestions are given to assist you in doing a good job of soldering.

When removing insulation, take care to avoid producing cuts or nicks in the wire. This greatly reduces the mechanical strength of the wire, especially under conditions of vibration.

The parts to be soldered must be absolutely clean and free of oxides, corrosion, and so forth. The joint should be prepared just before soldering. The prepared surface will soon corrode or become dirty if it remains exposed to the air. Also, the parts to be soldered must be securely joined mechanically before any soldering is done. Do not hold the work in your hand. Use a pair of pliers or other suitable clamping device to secure the work.

To solder an electrical connection (such as the splice in figure 10-49), hold the iron beneath the work. Get as much mechanical contact as possible to permit maximum heat transfer. Apply the 60/40 rosin-core solder to the splice rather than to the tip of the iron. The tinning on the soldering iron aids the transfer of heat to the spliced wire. When hot enough, the solder will melt. Before this temperature is reached, however, the rosin core flux will have melted and run over the wire to flux the splice. When the solder has coated the splice completely, the job is finished. No extra solder is needed.

Occasionally some special techniques are required in soldering. In equipment using miniature components, the intense heat from a soldering operation can damage nearby sensitive components. For example, small resistors can suffer permanent changes in their resistance values because of overheating.

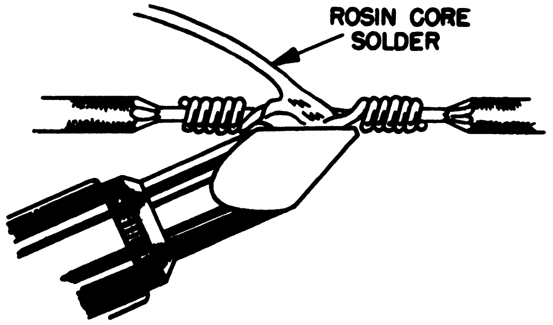


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Figure 10-49.—Soldering an electrical connection.

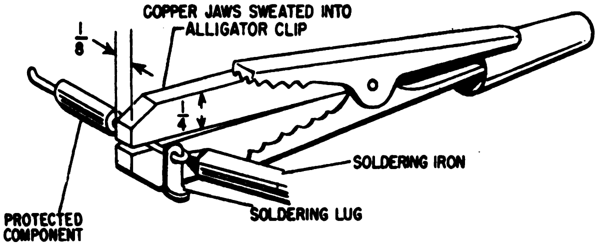

Figure 10-50.—A heat shunt or heat sink.

Overheating of resistors and other components during soldering can be avoided only by restricting the heat conducted along their connecting leads. The most acceptable means of preventing this overheating is to use a thermal (heat) shunt or heat sink (figure 10-50). The primary rule is to connect the shunt between the solder point and the component to be protected. Place the shunt as close to the component and as far from the joint as possible. The shunt will draw (conduct) the heat away from the component and protect it from damage. The shunt shown in the figure is a typical alligator clip with small pieces of copper inserted between its jaws. Hemostats or needle-nose pliers also could be used.

Good and Bad Soldered Joints

Let us consider the end product of a soldering operation—the joint. Various good and bad examples are shown in figure 10-51.

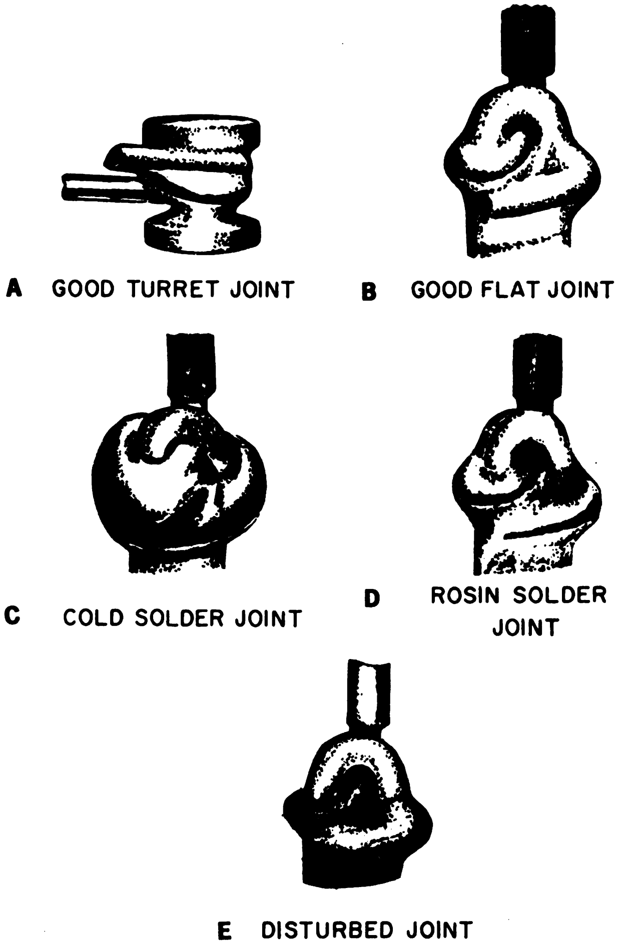
A GOOD TURRET JOINT
B GOOD FLAT JOINT
C COLD SOLDER JOINT
D ROSIN SOLDER JOINT
E DISTURBED JOINT

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Figure 10-51.—Examples of good and bad soldered joints.

A good, well-bonded connection is clean, shiny, smooth, and round. The examples seen in view A and view B are good connections. They show the approximate outline of the wire and terminals. The wire and terminals are completely covered, and the solder adheres firmly. The insulation is close to (about 1/16-inch) but not in the terminal hole or slot. Additionally, the insulation is not charred, burned, nicked, or covered with rosin. A film of rosin may remain on the joint and need not be removed unless fungus-proofing is anticipated.

Soldered joints may be defective for various reasons. A cold solder joint is shown in view C. It has a dull appearance and a crystallized texture. Because of the poor union between the wire and terminal, the joint will in time develop high resistance as the metals oxidize. This type of joint is generally caused by insufficient heat during soldering. It may be the result of too low a wattage soldering iron, a tip that was too small, or poor contact between iron and joint. A cold solder joint may be repaired by reheating. However, it may be necessary to take the joint apart and resolder it if dirt or oxide covers the wire.

A rosin joint (view D) is so named because the wire is held by rosin rather than solder. The flux is spread over the terminal and, instead of the solder bonding with the terminal, it (the solder) settles on top of the rosin. The joint may have all the appearances of a good joint, but a little pressure will cause movement or an ohmmeter will indicate an open. A rosin joint occurs by using a "cold" iron or one that is too small. In most cases, merely reapplying a hot iron will correct a rosin solder joint.

A disturbed solder joint (view E) has an irregular or crystallized appearance. The solder may be chipped off with a fingernail or a pointed tool. A disturbed joint is caused by the wire being moved before the solder has fully set. Since it may loosen later in service, a disturbed joint should be repaired in the same manner as the cold solder joint.

An insufficient solder joint can introduce high resistance in the circuit and, as current flows, create undesirable heat. It can loosen and cause an open or intermittent operation depending upon the amount of oxide present. An abnormal heat buildup or a visual inspection might reveal this condition, but it may be necessary to use an ohmmeter to detect this type of solder joint. To repair an insufficient solder joint, it should be taken apart. After cleaning off the oxide, the joint should be resoldered correctly.

A no-solder joint may cause intermittent equipment operation because of oxide or vibration, or the circuit may open entirely. A visual inspection and an ohmmeter check should indicate this condition. The joint should be taken apart, cleaned, and resoldered correctly. There are many other types of soldering defects, such as excessive solder or loose solder. The insulation also can be too close or too far from the joint. Invariably these defects can be traced to the technician making the connection.

Procedure for Soldering Wires to Connector Terminals

One of the most difficult and exacting jobs is soldering wires to connector terminals. The terminals or pins are all jammed together in a small space, leaving little room to work. Figure 10-52 shows a typical connector and part of the soldering procedure used to connect the wires to the terminals (pins).

If the connector is installed in a panel or fastened in a jig, you should start soldering at the side away from the iron. When the connector is free and you can hold it in your hand, you can solder with a stationary iron. Position the iron so that the tip is facing you and solder by holding the terminal and wire against the tip. When you use this method, start at the center of the connector and rotate it as your work continues.

Don't forget to tin the wires and terminals before you start to solder. Another preliminary step that is often forgotten is to put sleeving (insulation) over the wires. After you finish soldering and the work has cooled, slip the sleeving over the cooled joints. The sleeving should fit snugly over each soldered terminal and wire. Properly installed, the sleeving also helps support the wire and the soldered joint.

STRIPPING WIRE

Before soldering or crimping operations can be done, the end of a wire must be made bare. The act of removing a wire's protective insulation is commonly called stripping. Preferably, a hand-operated wire stripping tool should be used to

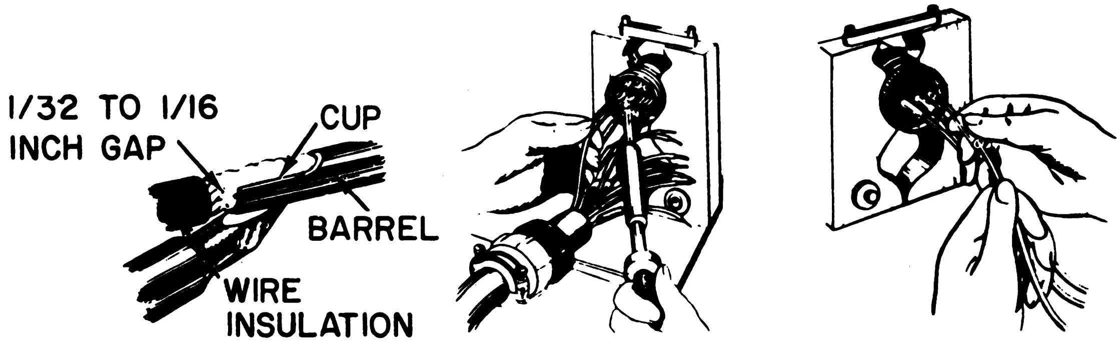

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Figure 10-52.—Soldering leads to connector terminals (pins).

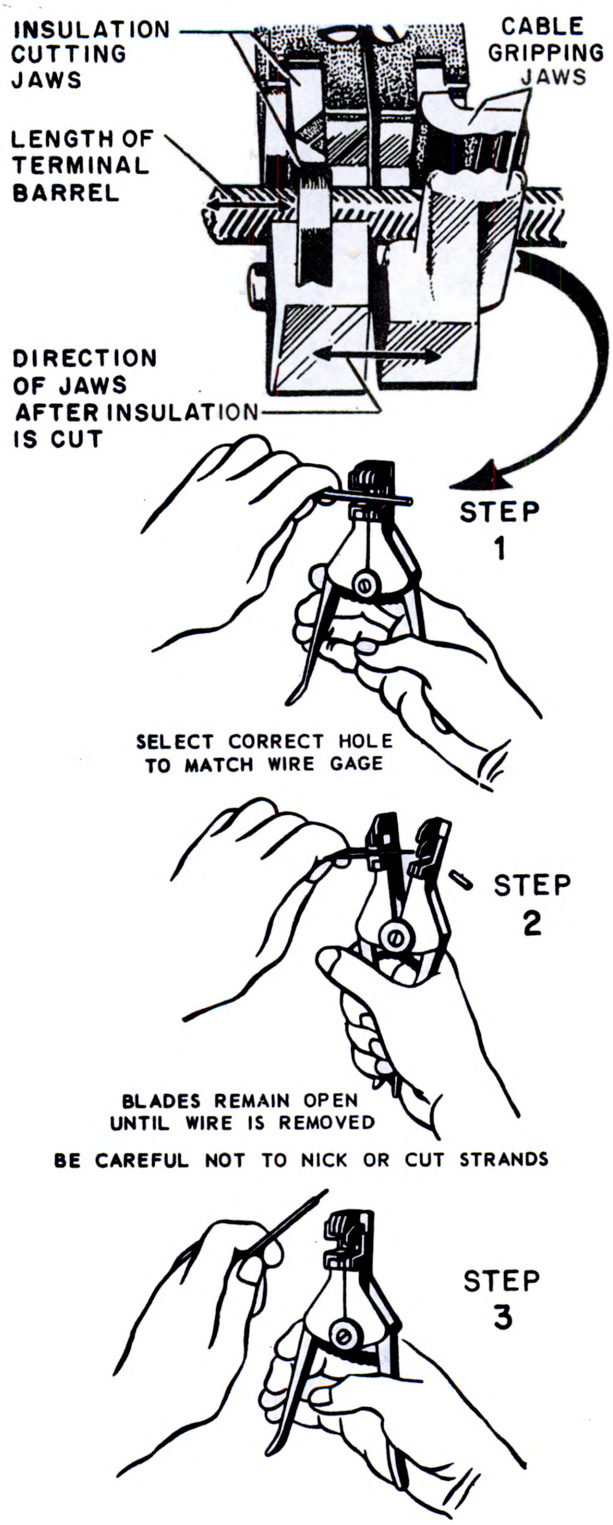
INSULATION CUTTING JAWS
CABLE GRIPPING JAWS
LENGTH OF TERMINAL BARREL
DIRECTION OF JAWS AFTER INSULATION IS CUT
STEP 1
SELECT CORRECT HOLE TO MATCH WIRE GAGE
STEP 2
BLADES REMAIN OPEN UNTIL WIRE IS REMOVED
BE CAREFUL NOT TO NICK OR CUT STRANDS
STEP 3

Figure 10-53.—Stripping insulation with a hand wire stripper.

remove the insulation. But a sharp knife or razor blade, used correctly, is an acceptable tool. With any method, take care to avoid nicking, cutting or otherwise damaging the metal conductor.

Figure 10-53 illustrates a typical hand wire stripper and how it is used. The cutting jaws of the tool are equipped with various cutting slots. Each slot is marked for a different wire size or gage. Insert the wire into the exact center of the correct cutting slot. Close (squeeze) the handles together as far as they will go. The gripping and cutting jaws will separate and strip the insulation from the wire. Release the handles to allow the gripping jaws to open.

There is a right way and wrong way to strip wire with a knife or razor blade. The knife should be held at about a 60° angle to produce a tapered cut as shown in figure 10-54.

When stripping wire with any tool, observe the following precautions:

1. Make sure all stripping blades are sharp and free from nicks, dents, etc.
2. When any type of wire stripper is used, hold the wire perpendicular to the cutting blades.
3. Make sure the insulation is clean-cut with no frayed or ragged edges. Trim if necessary.
4. Make sure all insulation is removed from the stripped area. Some types of wires are supplied with a transparent layer of insulation between

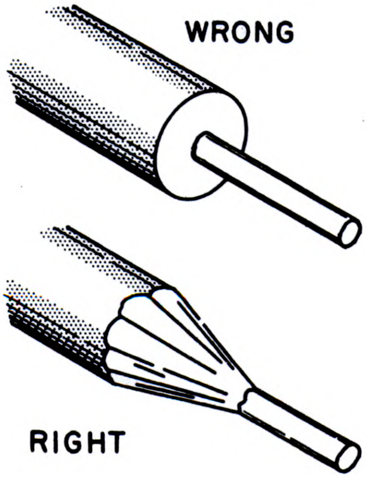

Figure 10-54.—Knife stripping.

the conductor and the primary insulation. If this is present, be sure to remove it.

5. When hand strippers are used to remove lengths of insulation longer than 3/4 inch, the stripping must be done in two or more operations. The strippers will only strip about 3/4 inch at a time.

6. Retwist bare wire strands by hand. This restores the natural lay and tightness of the strands.

INSULATING WIRE

Bare wire connections must be protected by some form of insulation to eliminate a shock hazard. The insulation also prevents the conductor from creating a short or ground and reduces deterioration. Rubber, friction, and plastic electric tapes are popular insulating materials. They are particularly useful in covering splice connections. These tapes should be applied smoothly and under tension so no air gaps exist between wraps. Generally, two to several layers are preferred when wrapping the conductor. Wind the tape so that it spirals and each turn partially overlaps the one before it. The tape should cover part of the conductor's original insulation on either side of the connection.

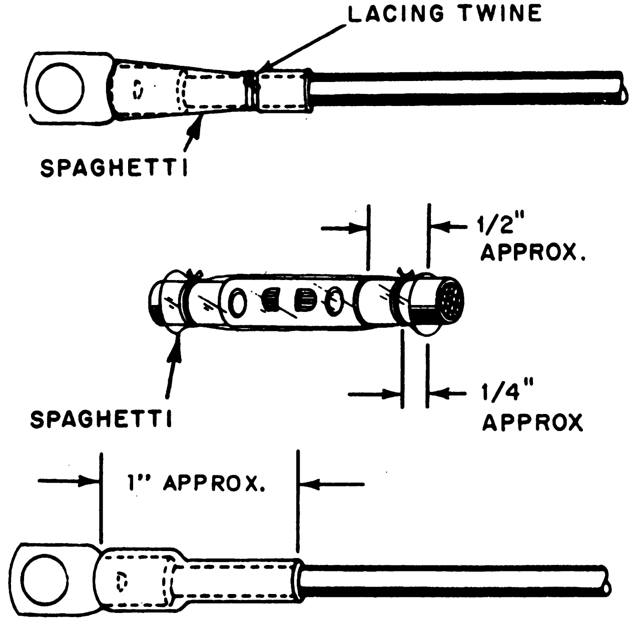

Figure 10-55.—Tubing insulation; spaghetti-type tubing and heat shrink-type tubing.

Two other types of insulators used to protect terminal and splice connections are transparent tubing (commonly called spaghetti) and heat-shrinkable tubing. Refer to figure 10-55. Tubing insulation is available in various diameters, so use the size closest to the wire's gage. If the spaghetti type of tubing is used, it should be tied with a lacing twine to keep it in place.

Heat-shrinkable tubing (commonly called heat shrink) is shrunk to the desired size by applying dry heat. It is a very desirable way to insulate terminals and splices because it forms a tight fit over the connection. The tubing shrinks to approximately one-half its original diameter when heated. The heat source should be held a few inches away from the tubing and wire. Rotate the wire or heat source to distribute the heat evenly. Remove the heat as soon as the tubing conforms to the shape of the wire and permit it to cool. Too much heat or a long application of heat will not cause the tubing to shrink further. Generally, the tubing starts to char or burn and then it is ineffective as an insulator. A hot air gun is the recommended source of heat. However, if you are very careful, the flame from a match or lighter can be used to shrink the tubing.

TERMINAL CONNECTIONS

Terminal connections are an essential part of any electrical circuit. They are used to connect the conductor to a load or connection point (terminal board). All terminal connections must be made correctly. They must also be mechanically and electrically sound and kept in good repair.

We can consider terminal connections in two general classes. First, there are solderless connectors (commonly called terminal lugs) that are mechanically crimped onto the wire. Second, there are solder-type connectors which require the wire to be soldered to them.

Terminal Lugs

In electronic equipment, almost all of the permanent connections are made by soldering. However, in the electrical systems of GMLSs, permanent connections usually are made with crimp-on terminal lugs. Crimping avoids some of the limitations of soldered terminals. The reliability of soldered connections depends mostly upon a technician's skill. Such factors as temperature, flux, cleanliness, oxides, and insulation damage caused by heat all affect the quality of a soldered connection.

The crimp-on or solderless terminals are very easy to use. Another advantage is that the only tool necessary is a crimping tool. The connections are made rapidly and are cleaner and more uniform. Properly done, a crimped connection has an electrical resistance that is less than an equivalent length of wire.

The basic types of terminal lugs are shown in figure 10-56. There are variations of these types, such as the use of a slot instead of a terminal hole. Various size terminal or stud holes will be found for each of the different wire sizes. A further refinement of the solderless terminal lug is the insulated terminal. The barrel of the terminal lug (figure 10-57) is enclosed in an insulating material. The insulation is compressed along with the terminal barrel, but is not damaged in the crimping process. This eliminates the necessity for taping, tieing an insulating sleeve, or shrinking tubing over the joint.

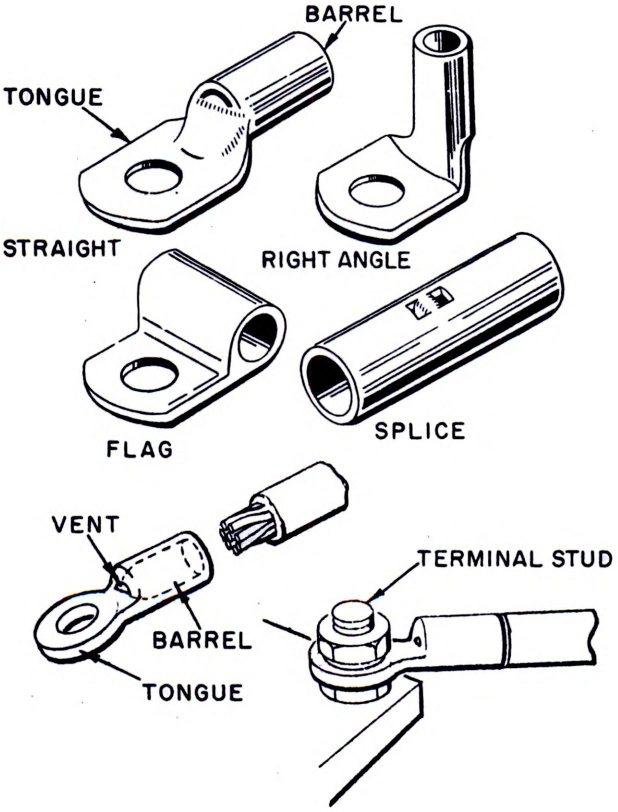

Figure 10-56.—Crimp-on or solderless terminal lugs; noninsulated types.

There are two types of crimping tools used with copper terminals. For wire sizes AWG (American wire gage) 10 or smaller, a pliers type of crimper is used. The jaws on this type of crimper have several sizes of notches for the different size terminals. A larger pincer-type of crimper must be adjusted to an index mark for the various size terminals. Take care to select the correct crimping tool for a particular terminal.

The procedure for crimping a copper terminal to a small copper wire is illustrated in figure 10-58.

1. Strip the cable insulation carefully to avoid cut or nicked strands. Remove the proper length

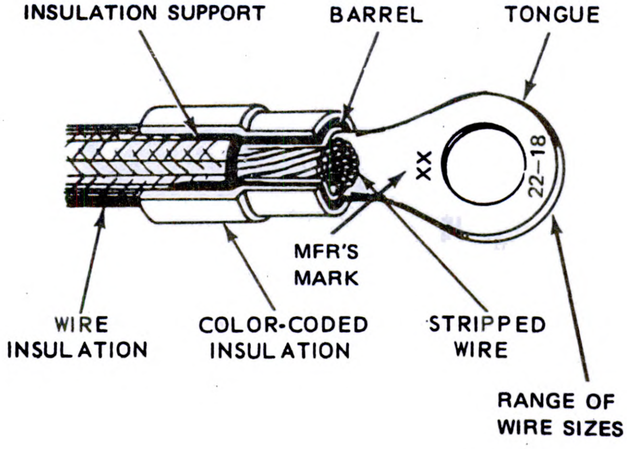

Figure 10-57.—Preinsulated solderless terminal lug.

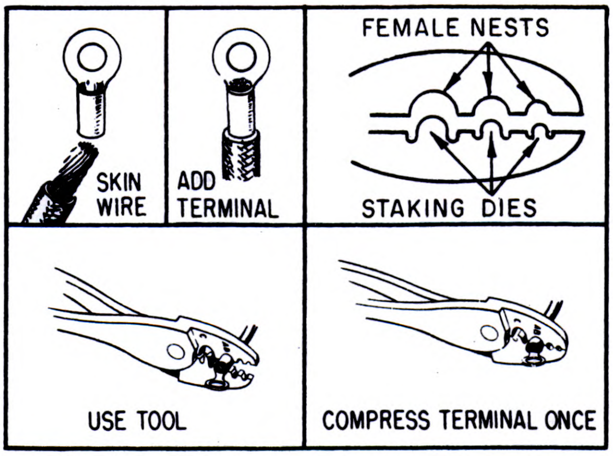

Figure 10-58.—Crimping a wire to a terminal lug.

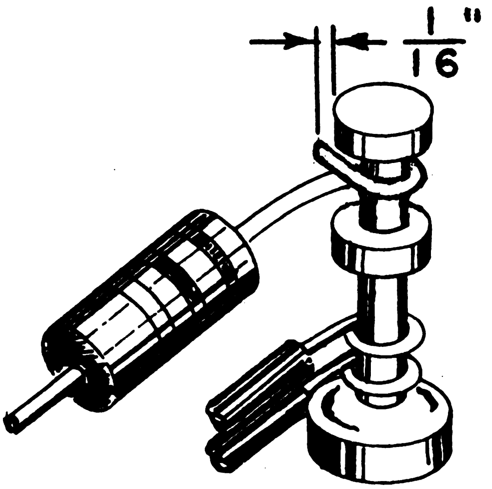

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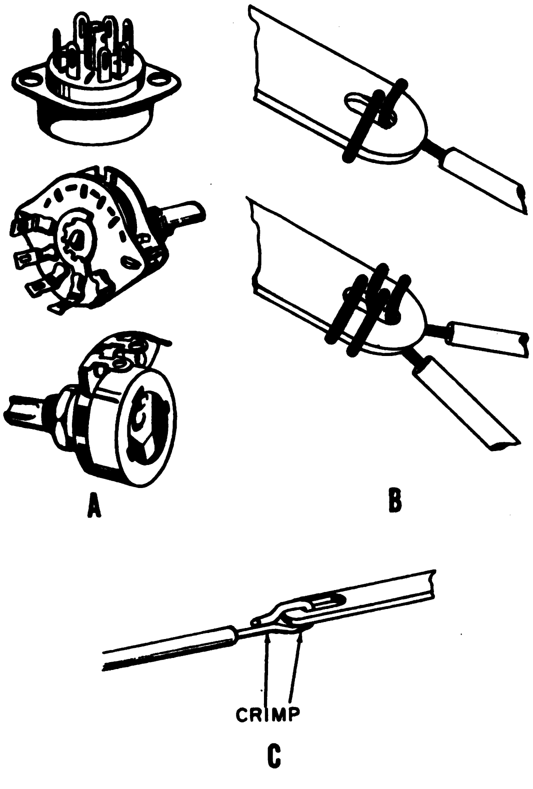
Figure 10-59.—A correct wrap on a turret or stud terminal.



83.128:129

Figure 10-60.—Flat terminals: A. Component applications; B. Correct wraps; C. An alternate connection method.

of insulation. Do not tin stranded wires that will be crimped.

2. See that the stripped cable end extends into the terminal barrel for the full length of the barrel.

3. Center the terminal barrel in the jaws of the crimping tool. This will ensure that an even pressure is applied to the wire when the terminal is crimped.

4. Crimp the terminal, making sure that the crimper is fully and firmly closed.

5. Inspect the connection and give it a firm tug. If the terminal lug and wire survive this "acid" test, you have done a good job of crimping.

Any crimping operation should be performed carefully. Improper procedures will eventually cause terminal failure. Be particularly careful of undercrimping and overcrimping. A loose contact will allow an oxide film to form between the wire and terminal and create an increased resistance at the connection.

If the correct tools and proper procedures are used, crimped connections will be more effective electrically, as well as mechanically, than soldered connections. A visual inspection is very important for it will reveal oxidation, deterioration, overheating, and broken conductors. In some cases it may be necessary to check these connections with an ohmmeter. The proper resistance, for all practical purposes, is zero. Any defective terminal lug should be removed and a new terminal crimped in its place. Do not try to reuse old terminal lugs.

Solder-Type Connections

There are four basic types of solder-type terminal connectors—turret (or stud), flat, hook (or eyelet), and split. The turret, or stud, terminal (figure 10-59) is used primarily on component mounting boards. To make a wire connection, wrap the lead 1-1/2 turns around the terminal. The lead can be crimped if necessary. Clockwise wrapping is preferred because there is a natural tendency for people to unwind the wire in a counterclockwise direction.

The flat, perforated terminal (figure 10-60) is used on most tube sockets and potentiometers. To make the wire connection, insert the wire through the hole and wrap 1-1/2 turns around the body of the terminal. If you use heavy wire, or space does not permit you to wrap properly, you can make a good mechanical connection by crimping. Feed the wire through the hole, bend it around the lug 180°, and crimp firmly as seen in view C of the figure.

The hook, or eyelet, terminal (figure 10-61) is used on certain relays such as a Hi-G relay. To make a good mechanical connection on this type of terminal, feed the wire through the loop and wrap it one full turn around the shank.

The split terminal (figure 10-62) is often used on transformers and other heavy components. Lay the wire in the slot and wrap it 1-1/2 turns around the body of the terminal.

We have emphasized the point of making a good mechanical connection for solder-type terminals. No connection should depend upon the strength of solder alone for security because solder is relatively soft. All electrical connections should be made mechanically strong before they are soldered. If you crimp or wrap a wire tightly around the terminal post, you will have a secure base upon which to solder. Properly done, crimping or wrapping prevents disturbing the joint during soldering and while the solder is cooling.

To make a good mechanical connection, you don't have to wrap the stripped end of the wire around the terminal two or three times. As mentioned earlier, 1-1/2 turns are enough to make the connection mechanically strong. If you put on more turns, they add nothing to the strength of the connection and simply make it more difficult to remove later. Bring the end of the insulation as close to the terminal as possible. Also, the wire should be wrapped so that tension on the wire will be transmitted to the terminal and not to the solder. After you finish making the connection, but before you begin soldering, cut off the end of the lead. Leave about 1/16 inch of lead extending from the connection. That leaves enough wire to get a grip on when you need to remove the connection later.

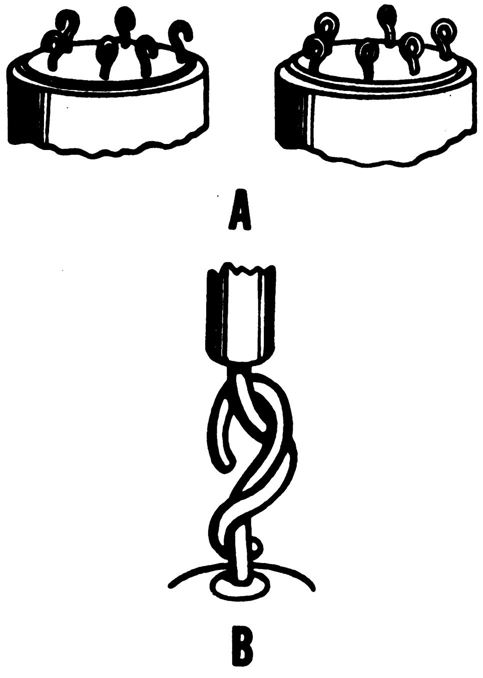


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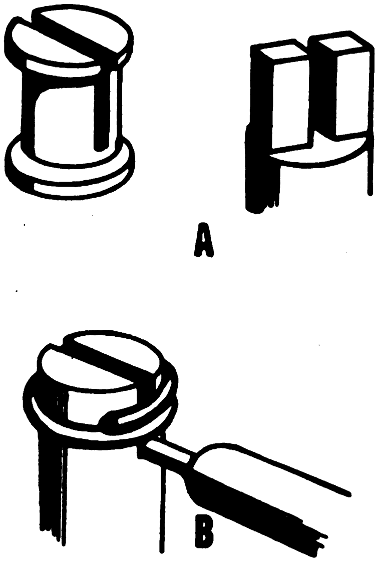
Figure 10-61.—Hook or eyelet terminals: A. Component applications; B. Correct wrap.



83.131
Figure 10-62.—View A—types of split terminals; View B—correct wrap.

SPLICE CONNECTIONS

As a general rule, cable splice connections are not recommended for ordnance work. However, under emergency situations, splicing may be necessary to continue operations. Permanent repairs should be made as soon as possible thereafter.

Figure 10-63 illustrates how two popular splices—Western Union and rattail—are made. To increase its strength, the splice may be soldered. (Refer to figure 10-49.) In multiconductor cables, a smoother and less bulky joint can be made by staggering the splices. View C of figure 10-63 shows two Western Union splices staggered. Each connection must be taped for separate insulation purposes.

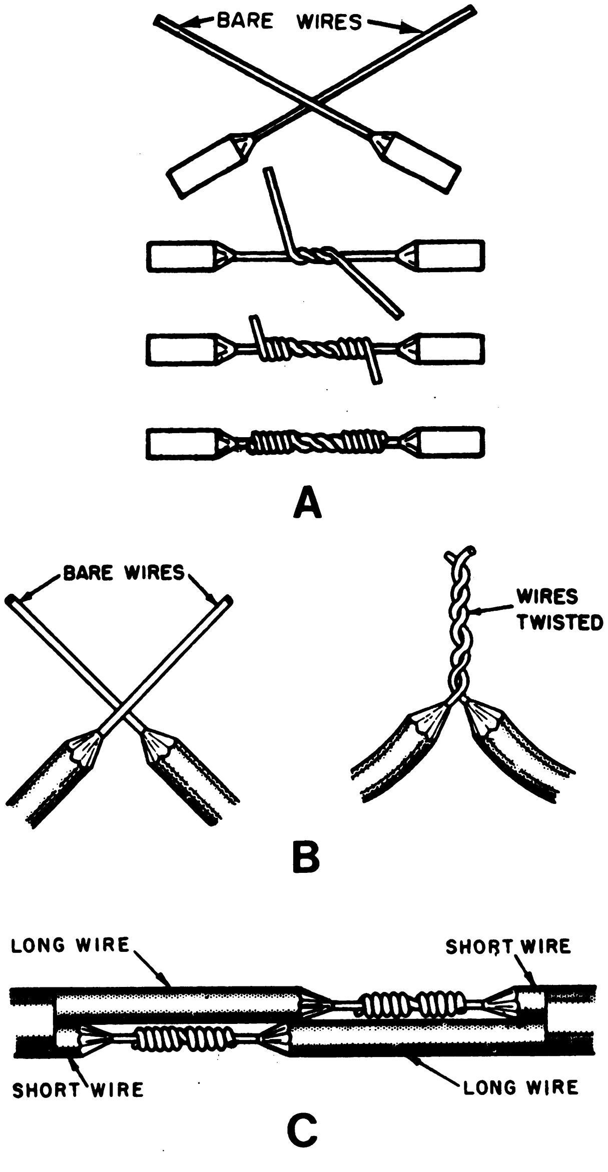


Figure 10-63.—View A—making a Western Union splice; View B—making a rattail splice; View C—staggering two Western Union splices.

Inline wire splices also may be made with special crimp-on connectors. Figure 10-64 illustrates a preinsulated copper splice connector. Noninsulated connectors are available but require some type of electrical tape or insulated (shrink) tubing for protection. Standard crimping tools are used to make the mechanical connection.

LACING AND TIEING

Look inside the average EP2 control panel and you will find several thousand individual conductors connecting terminal boards, relays, switches, and so forth. Even the smaller electrical connection boxes contain a multitude of wires. To be maintainable, these conductors must be arranged in an orderly fashion. They should present a neat appearance, be firmly secured in place, and be clearly marked or identified.

Lacing is the practice of tieing conductors into bundles or groups. Sometimes these bundles are referred to as cable harnesses or wiring harnesses. Figure 10-65 illustrates an example of a well-laced, properly harnessed cable run. The wires are neatly arranged and formed so circuit tracing is easy. They are well supported and located to permit ready access to circuit components. The conductors run parallel or at right angles to each other and sharp bends, which may damage the wire or its insulation, are avoided.

NEETS Module 4 describes various lacing techniques and explains how they are done. Several popular lacing and tieing styles—single lacing, double lacing, and spot tieing—are shown in figure 10-66.

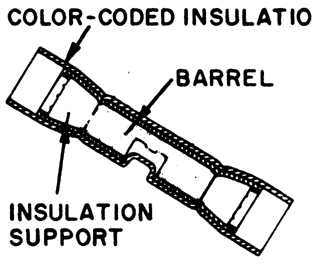


Figure 10-64.—A preinsulated inline copper splice.

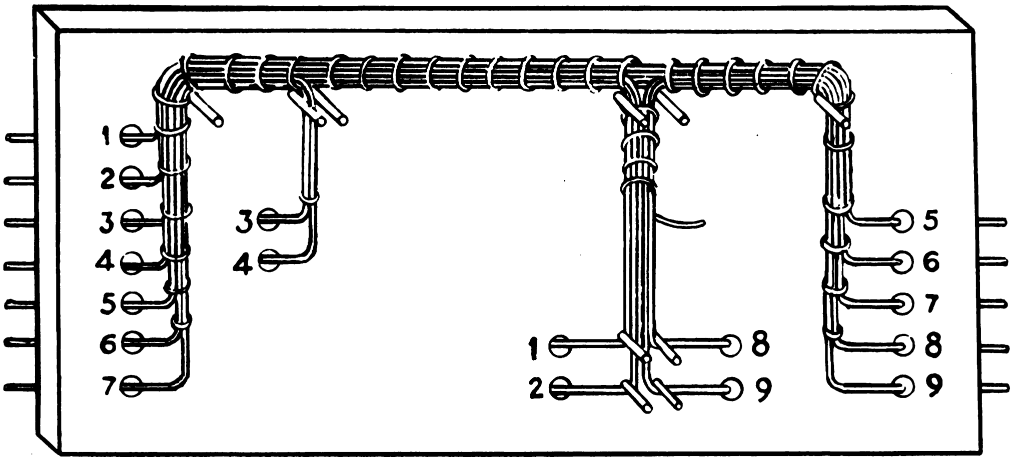


Figure 10-65.—A well run cable haruess.

A narrow flat tape should be used for most lacing and tieing operations. Lacing or lacing cord (as it is commonly called) is usually available on a spool. It is not an adhesive material, although it feels sticky. That is because it is prewaxed to make it moisture and fungus resistant. Small round cord or line can be used as lacing, but it is not preferred. Round cord can cut into a wire's insulation.

Self-clinching cable straps are quire popular for tieing operations. They are adjustable, lightweight, flat nylon (plastic) straps. Ribs or serrations are on the inside surface of the strap. They are used to grip the wire and the strap's locking clip. Nylon straps may be used instead of lacing ties for securing wire groups or bundles quickly.

Figure 10-67 illustrates how self-clinching nylon straps are installed with the use of a strap tool. If the tool is not available, the straps can

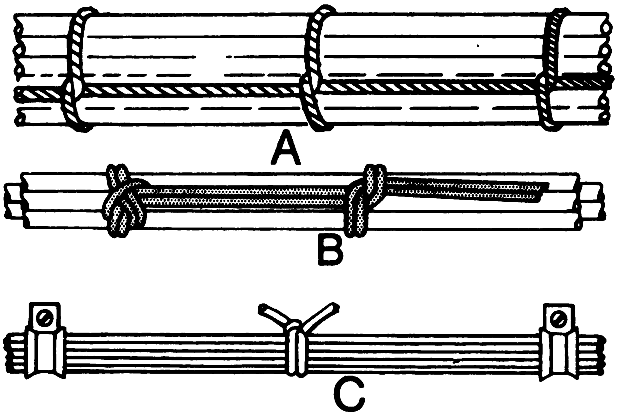


Figure 10-66.—Lacing and tieing styles: A. Single lacing; B. Double lacing; C. Spot tieing.

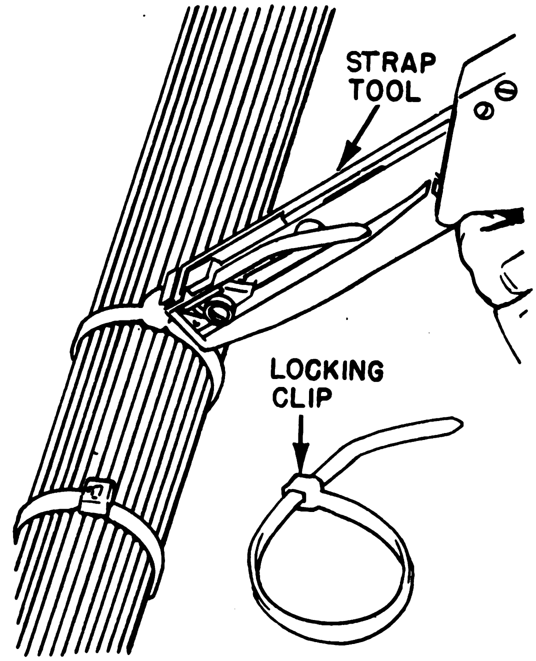


Figure 10-67.—Installing self-clinching nylon cable straps with a strap tool.

be installed by hand and pulled secure enough for the job. After the strap is fastened, the excess end must be trimmed flush with the strap's eye or locking clip. Be sure to cut the excess as flush as possible. Otherwise, a very sharp, protruding piece of hard plastic will be sticking out that can cause some painful injuries.

Before you start a lacing or tieing operation, lay the conductors out straight and parallel to each other. Do not twist them together as this makes it harder to trace the wires and looks sloppy. Lace or tie the bundles tightly enough so the wires do not slip or ride over each other. But do not pull the lacing so tight that it cuts into or deforms the conductors' insulation.

Spare conductors of a multiconductor cable should be laced separately. When two or more cables enter a panel or connection box, they should be laced separately too. Be especially careful lacing coaxial cables. Coaxial cable is a special conductor used for radio frequency (RF) transmission signals. It consists of a center conductor separated from an outer conductor (or shield) by an insulating dielectric. The dielectric maintains a constant capacitance between the two conductors, which is very important in RF transmissions. The dielectric is soft and can be deformed/damaged quite easily if the lacing is pulled too tight.

There will be times when you must undo cable lacing to make troubleshooting easier or when replacing a damaged cable. After the repair job is finished, be sure to relace the conductors. Use the approved materials and do a proper job; neatness counts!

GENERAL MAINTENANCE— CONCLUSION

At this point we conclude our discussion of general maintenance procedures and techniques. No one training manual or technical publication can possibly cover everything you need to know regarding maintenance. Nor will everything be written. You will learn many new skills through experience and on-the-job training. As you perform your maintenance tasks, keep alert for new procedures and look for easier methods. Do the work carefully, think the job through, and observe all applicable safety precautions. Remember (1) there is no substitute for quality, professional workmanship and (2) an ounce of preventive maintenance is worth a pound of corrective repairs!

For additional information on maintenance-related subjects, we recommend you consult the following references.

1. NEETS Module 4, *Introduction to Electrical Conductors, Wiring Techniques, and Schematic Reading*
2. NAVPERS 16193 series, *Fluid Power*
3. NAVEDTRA 10077 series, *Blueprint Reading and Sketching*
4. NAVPERS 10085 series, *Tools and Their Uses*
5. NAVSEA OD 3000, *Lubrication of Ordnance Equipment*
6. OPNAVINST 4790.4, *The Ships' Maintenance and Material Management (3-M) Manual*

CHAPTER 11

TROUBLESHOOTING AND TESTING

The primary subject introduced in this chapter is troubleshooting. Troubleshooting may be defined as the art of locating the cause of an equipment casualty. As a Gunner's Mate assigned to maintain complex and sophisticated ordnance equipment, you must develop good troubleshooting skills. You must also have a firm understanding of the basic trouble isolation procedures. You also must be able to make effective use of available troubleshooting aids and test equipments.

Most of the following information explains electrical/electronic troubleshooting techniques. However, you can apply the basic philosophies described here to hydraulic, pneumatic, and mechanical areas as well.

TROUBLESHOOTING

As we stated earlier, troubleshooting is the ART of LOCATING THE CAUSE of an equipment casualty. We can say troubleshooting is an ART because it is a skill that requires some talent. That skill is acquired after years of experience, study, and observation. At this point in your career, you are NOT expected to be Mr. Super Technician or an expert troubleshooter. Right now you should concentrate on learning the basics of the trade. In time, your troubleshooting skills will improve.

We emphasized the phrase LOCATING THE CAUSE in the last paragraph. That phrase identifies the primary purpose or goal of troubleshooting. When an equipment casualty occurs, look for and find the exact cause of the problem. After you know what is wrong, take corrective actions to restore the equipment to operational status. You will hear the terms UP and DOWN used to describe the equipment's status. The gear is UP when it is capable of performing its mission. The gear is DOWN when a casualty reduces the equipment's operational capabilities.

Here are a few general tips and pointers that can help you become a better troubleshooter.

1. Know your equipment. Be familiar with its operation in all modes of control. Be able to locate major system components.
2. Observe the equipment. Watch for changes in operating speeds or travel distances. Listen for strange noises. Weird "bangs" and "clunks" are good indicators that something is wrong.
3. Observe experienced troubleshooters in action. Note how they approach a casualty and study their troubleshooting techniques. Ask questions if you don't understand a procedure.
4. Troubleshooting is a team effort. Everyone has a different idea of how to troubleshoot. Be willing to share and exchange your ideas with others.
5. Don't be afraid to troubleshoot. It can often become complex and frustrating work, but don't give up. Should one idea fail, try another. Get involved with the problem. In the end, troubleshooting is challenging, exciting, and rewarding work.

TYPES AND CAUSES OF CASUALTIES

The term "casualty" is used to describe various equipment conditions, all of which can be broadly classified as incorrect. Consider, if you will, an accumulator-type power drive. You push the motor's START button but nothing happens. What's wrong—a bad motor or a defective control circuit? At that moment, you can only assume a casualty exists because the equipment has failed to operate.

In another situation, the equipment may operate, but won't function properly. Consider a simple one-speed TX-TR synchro system used to turn a dial. You move the TX from 0° to 45° and the TR turns the dial. But the dial stops at 40°, 5° short of where it should have synchronized. The synchro system has a casualty; not because the system failed to operate, but because it failed to function correctly.

You probably can think of several other similar examples. However, in troubleshooting, we are more interested in finding the cause of the casualty. Most equipment casualties eventually can be traced or isolated to one of the following problem areas:

1. Part breakdown or failure
2. A malfunction without breakdown
3. Operator error

Part Breakdown

The component parts of our equipment are well-designed, thoroughly tested, and constantly inspected. But they are not infallible and can break or fail even under ideal conditions. Current surges may cause a relay coil or transformer winding to burn open. Metal fatigue can cause a shaft to bend or snap. Inadequate lubrication speeds up friction damage, and moving parts, such as bearings, can freeze. Physical damage and corrosion are major causes for part breakdown. (Corrosion-related failures are especially acute on forward-mounted launchers that get hit with extra amounts of salt spray and waves.)

Casualties resulting from part failure normally are corrected by replacing the defective item. In certain instances, some failed parts can be rebuilt or repaired. Bent rods can be straightened and cut electrical cables can be spliced. However, such repairs should be made under emergency conditions only and considered temporary. As a general rule, it is better to replace a broken part than try to fix it.

Malfunction Without Breakdown

Not all equipment casualties are the result of a part failure. That is true of many of the problems you will encounter.

Vibration is a very common cause for malfunctions without breakdown. The wires of a cable are connected to terminal board points by tiny screws. Over a period of time, ship vibrations cause the screws to become loose and (possibly) fall from the terminal board. The wire drops off and we have lost electrical continuity in a circuit. Yes, that is a casualty; no, a part did not break. After you isolate the problem (find the loose or disconnected wire), repairs are simple—reconnect the wire to restore the circuit.

All electrical connections and connectors (plugs/jacks) are subject to troubles from vibration. Hydraulic and pneumatic fittings and any fastening device (nuts, bolts, and so on) fall into this category. Maintenance inspections, safety wiring, and the like should eliminate many of these potential problems. Make it a habit to check the tightness of such items anytime you see them. This practice will save you many hours of troubleshooting.

Another common cause for malfunctions without breakdown can be traced to normal wear and tear. In other words, old age creeps up on some components. The ohmic value of a potentiometer or resistor can change over the years. As a result, a circuit's potential or output can vary. Synchros suffer a similar problem. Mechanical gear trains develop "slop" or lost motion as they wear. Troubles such as these are bound to happen. Normally, an adjustment/realignment is made to compensate for any wear or changes in values.

A ground in an electrical control system is another example of a malfunction without breakdown. Moisture is a common cause for a ground. After you find the grounded circuit and dry out the moisture, the problem is corrected in most cases.

You can probably think of many more examples of malfunctions without breakdown. Generally, the repair work necessary to correct such problems is simpler and less costly. However, finding the cause of a malfunction without breakdown can tax your troubleshooting skills. That is because the trouble is not as apparent nor stands out like a broken part does.

Operator Error

Unfortunately, many equipment casualties can be traced to causes resulting from operator error. For the most part, operator errors are human mistakes. As a troubleshooter, always stay alert for operaor error casualties.

Inexperience, especially in the operation of a GMLS control panel, is a major factor behind many operator-induced casualties. Often a switch is turned to a wrong position or a pushbutton is depressed out of proper sequence. As a result, the equipment does not perform a desired function. Initial indications point to a "real" casualty. The problem is not in the equipment—thank goodness for safety interlocks! The casualty is in the operator's having made a mental mistake.

How do you troubleshoot this type of casualty? Your first reaction should be to check the control panel. Ensure all switches are in their correct position for a desired operation. Also, study the panel's indicating lamps and other status displays or readouts. They are designed to show the condition of the equipment and are valuable sources of troubleshooting information. These steps—checking switches and lamps—should be done anytime the equipment fails to operate properly.

Neglect is another (unpopular) cause behind operator error casualties. For some reason, posted instructions and standard operating procedures are ignored, a short cut is tried, or a safety regulation is violated. As a result, a "real" casualty is introduced into the equipment unnecessarily. More seriously, the safety of the ship and its personnel can be endangered too.

Can casualties caused by operator error ever be eliminated? Obviously, the answer is no, but there are several means available to help reduce the number of such problems. The two best methods are (1) training and (2) supervision.

CASUALTY ANALYSIS

The preceding information should give you a better idea of the types and causes of casualties you may encounter. It would be impossible to predict which problems you will see most often. Therefore, keep an open mind about any casualty as you begin troubleshooting procedures.

It should be evident by now that troubleshooting essentially is an exercise in problem solving. The work is about 90 percent mental and only 10 percent manual. The key to effective troubleshooting is for you to use a logical approach in solving the problem. If troubleshooting is allowed to become a hit-or-miss affair, precious time and manpower are wasted.

The logical troubleshooting process can be divided into two major phases—casualty analysis and trouble (or fault) isolation. Both areas are important and sometimes overlap each other. We will discuss the different steps or actions of the casualty analysis process first.

Although the initial step of casualty analysis may sound simple, it should not be taken lightly. You must be able to recognize a NORMAL equipment condition. In other words, you must understand the gear and be familiar with its operation in any mode of control. This knowledge is obtained through formal courses of instruction and from on-the-job training. It also can be gained by asking senior personnel questions and by studying the equipment OPs/TMs.

The second step of the casualty analysis process can be more difficult. You must have the ability to recognize that a problem (1) has already occurred, (2) is occurring, or (3) is about to occur. The first and second steps of casualty analysis are closely related. In short, you must know what is right before you can say something is wrong.

The third step of the casualty analysis process falls right into place once you are sure a problem exists. You must collect all available data about the problem and its symptoms. How do you do that? Watch the equipment operate, listen to it, double-check the control panels, and so on. If you were the panel operator when the problem occurred, retrace your actions. If someone else was operating the panel, have them recall all events leading up to and including the casualty. Deal with facts and ask questions. Was the equipment running or did it fail to energize? Were pressure and temperature ranges normal. Does the problem happen only during a certain set of circumstances? The smallest bit of information you gather now may be the solution in the end.

After collecting all the data available about the problem's symptoms, you are ready for the last step in the casualty analysis process. Either mentally or on paper, list all the possible causes for the given symptoms. Some technical manuals contain a "Problem-Cause-Solution" section in their troubleshooting chapter. It would be wise to consult such information, especially if you are not familiar with the particular problem. Discuss the problem and its symptoms with other work center members. They may have seen this casualty, or something similar to it, in the past. Given the symptoms, they might come up with several possible causes that were not immediately apparent to you.

Armed with the symptoms and possible causes, you can proceed to the next phase of troubleshooting—trouble isolation. We hope you understand the importance of the casualty analysis process. Take your time in gathering the information about a problem and do a thorough job. Do not jump to any conclusions or make snap decisions. Every equipment casualty is unique, so consider all the facts about each problem carefully.

TROUBLE ISOLATION

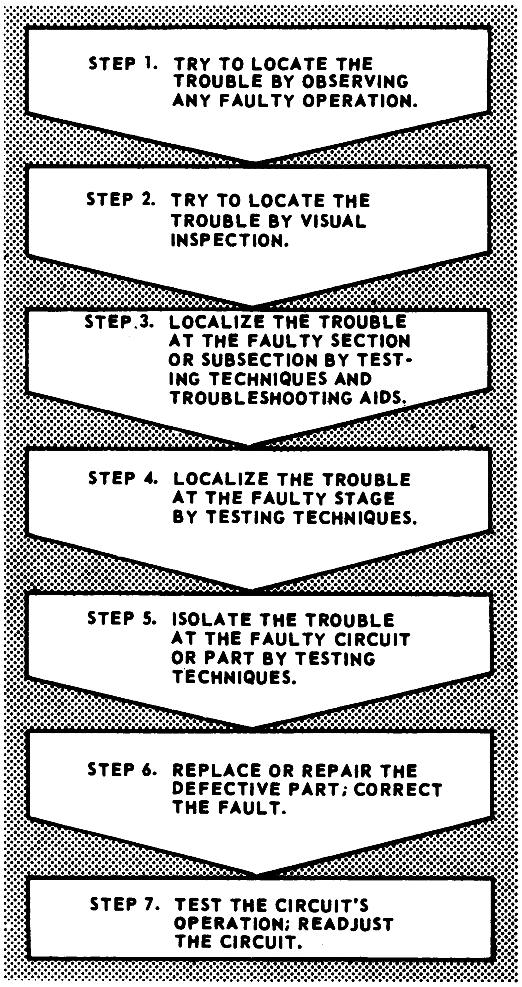
The second phase of the logical troubleshooting process is known as trouble (or fault) isolation. It refers to the procedures used to find the exact cause of an equipment casualty. Figure 11-1 identifies the seven major steps used in a typical trouble isolation procedure. Take a moment to read the information in each block.

The procedures outlined in the figure are general enough to be used for any type of troubleshooting work. They are listed in a logical sequence and are recommendations only. It is not mandatory that all seven steps be used to find and repair every casualty either. The following areas of the text discuss each step.

- Step 1: Try to locate the trouble by observing any faulty operation. That is a fairly basic procedure used to isolate any equipment problem. It also is very similar to the third step in the casualty analysis process. However, this time you should be able to observe the problem from a different point of view. You have had a chance to think about the possible causes. If the problem still persists, you will watch the equipment operate (if it can) with a more critical eye. You may have missed something the first time. A second, closer look is well worth the effort.

- Step 2: Try to locate the trouble by visual inspection. This step is very important and many casualties are solved/isolated at this point. Look for the simplest and most obvious defects first. Also, use your senses of hearing, smell, and touch to help isolate the problem.

If the cause of the trouble is located during steps 1 and/or 2, your troubleshooting work is done. You may move ahead to step 6 and make the necessary repairs. Try to keep the troubleshooting process as simple as possible. That is why we recommend you spend a little extra effort in step 2. Take your time and leave no stone unturned.


STEP 1. TRY TO LOCATE THE TROUBLE BY OBSERVING ANY FAULTY OPERATION.
STEP 2. TRY TO LOCATE THE TROUBLE BY VISUAL INSPECTION.
STEP 3. LOCALIZE THE TROUBLE AT THE FAULTY SECTION OR SUBSECTION BY TESTING TECHNIQUES AND TROUBLESHOOTING AIDS.
STEP 4. LOCALIZE THE TROUBLE AT THE FAULTY STAGE BY TESTING TECHNIQUES.
STEP 5. ISOLATE THE TROUBLE AT THE FAULTY CIRCUIT OR PART BY TESTING TECHNIQUES.
STEP 6. REPLACE OR REPAIR THE DEFECTIVE PART; CORRECT THE FAULT.
STEP 7. TEST THE CIRCUIT'S OPERATION; READJUST THE CIRCUIT.

12.259

Figure 11-1.—The logical steps of a trouble isolation procedure.

- Steps 3, 4, and 5: These steps can best be described as a logical process of elimination. They require the use of various testing techniques to isolate the cause of the casualty. Beginning with step 3, you test major sections or circuit areas suggested by the problem's symptoms. Eliminate the sections or circuits where the fault is NOT located. Progressively smaller sections or circuit stages are checked during step 4. Again, eliminate those areas where the fault is not located. In step 5, the testing process continued until the fault is isolated to a part or circuit. At this point, the cause of the problem should be revealed.

- Step 6: Replace or repair the defective part or correct the fault. Steps 1 through 5 are used to isolate the problem; step 6 fixes it.

- Step 7: Test the circuit's operation and readjust the circuit (if necessary). Casualty repairs should not be considered complete until the equipment has been thoroughly checked out. Do not be satisfied with one test result either. Hold a series of checks and test the different modes of operation. You may find it necessary to make a few final adjustments to finish the job. Also, be alert for any new problems that may have developed in the equipment.

Troubleshooting and corrective maintenance repairs are finished after everything is reassembled and your tools are put away. Access covers must be replaced and safety wiring reinstalled. Oil levels should be topped off and lubricants reapplied. The equipment area should be checked to ensure no tools, rags, or other foreign objects were left behind. Pay attention to these little details or you may have to begin troubleshooting again.

There is one other point associated with the troubleshooting process worth mentioning at this time. Be sure you keep your chain of command informed about a casualty. The personnel in the chain NEED to know when a problem occurs and how it affects the equipment's operational readiness. Be prepared to explain what is wrong and provide an estimated time of repair (ETR). You may need to request outside technical assistance or need help in obtaining a repair part. At the worst, a ship's commitment or scheduled exercise may have to be postponed. Such decisions must be made by the personnel in your chain of command. It is your responsibility to keep them informed.

LOGICAL TROUBLESHOOTING

You will find there are very few hard-and-fast rules dictating how you must isolate a casualty. However, there are several recommended practices and procedures you should follow to solve any problem. The steps and procedures described with the casualty analysis and trouble isolation processes are such examples/suggestions.

Above all, remember there is no substitute for a systematic, logical approach to troubleshooting. Be sure YOU use an orderly process of elimination to locate the cause of a problem. You might hear the term "easter-egging." It refers to a random, haphazard method of troubleshooting. Sometimes easter-egging is successful (if you are lucky); most of the time it is a counterproductive and ineffective effort.

Troubleshooting—that is, LOGICAL troubleshooting—is an exacting technical skill. Think before you act, ask questions, and keep the chain of command informed.

TROUBLESHOOTING DOCUMENTATION

Various troubleshooting documents have been developed under the planned maintenance system for surface missile systems (PMS/SMS). These documents are applicable to both the weapons system and individual equipment (GMLS) levels. They are designed to help you isolate and correct system and equipment faults.

Figure 11-2 shows the general relationship between weapons system level and GMLS level documentation. At this time, it is not necessary for you to have a detailed knowledge of every document listed. You should, however, be aware that such documentation exists and be familiar with its basic purposes. The procedures and diagrams contained in these documents lead to:

1. The alignment and adjustment of malfunctioning systems and equipments.
2. The repair and replacement of faulty components.

Although there are certain similarities between weapon system and guided missile launching system documentation, we will discuss each separately. Additionally, there are several different formats of SMS documentation. The examples presented in this text should be considered as typical. Even where different, our examples can be related to other formats in existence. The practical techniques of troubleshooting do not change.

WEAPON SYSTEM TROUBLESHOOTING DOCUMENTS

Weapons system maintenance documentation (figure 11-2, left side) applies to four functional periods. Those periods include (1) scheduled maintenance (system tests), (2) operation, (3) fault isolation, and (4) fault correction. System troubleshooting documents are designed to help you in two ways. First, they are used to locate

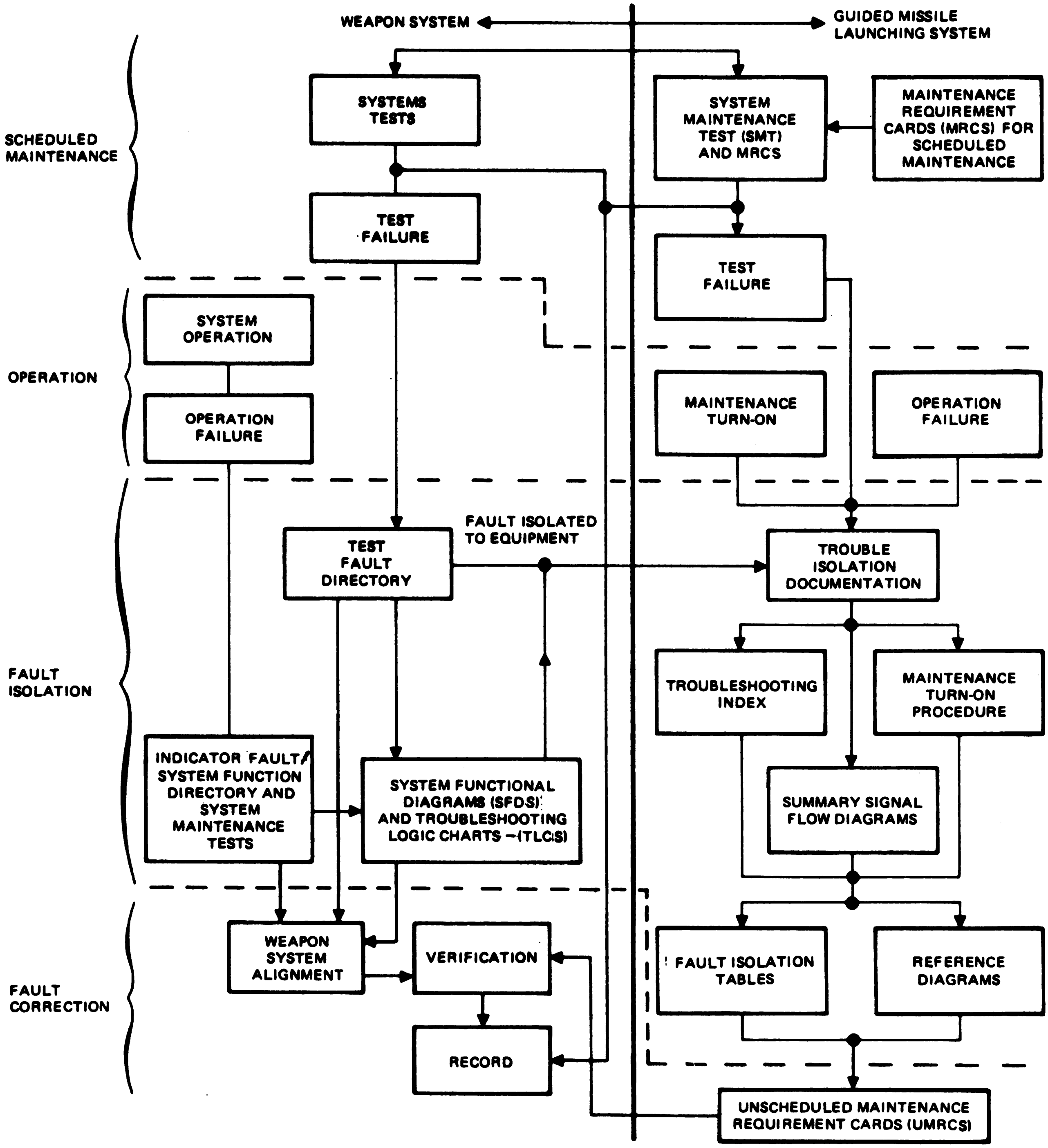

WEAPON SYSTEM
GUIDED MISSILE LAUNCHING SYSTEM
SCHEDULED MAINTENANCE
SYSTEMS TESTS
SYSTEM MAINTENANCE TEST (SMT) AND MRCS
MAINTENANCE REQUIREMENT CARDS (MRCS) FOR SCHEDULED MAINTENANCE
TEST FAILURE
TEST FAILURE
OPERATION
SYSTEM OPERATION
OPERATION FAILURE
MAINTENANCE TURN-ON
OPERATION FAILURE
FAULT ISOLATION
TEST FAULT DIRECTORY
FAULT ISOLATED TO EQUIPMENT
TROUBLE ISOLATION DOCUMENTATION
TROUBLESHOOTING INDEX
MAINTENANCE TURN-ON PROCEDURE
INDICATOR FAULT/SYSTEM FUNCTION DIRECTORY AND SYSTEM MAINTENANCE TESTS
SYSTEM FUNCTIONAL DIAGRAMS (SFDS) AND TROUBLESHOOTING LOGIC CHARTS —(TLCS)
SUMMARY SIGNAL FLOW DIAGRAMS
FAULT CORRECTION
WEAPON SYSTEM ALIGNMENT
VERIFICATION
RECORD
FAULT ISOLATION TABLES
REFERENCE DIAGRAMS
UNSCHEDULED MAINTENANCE REQUIREMENT CARDS (UMRCS)

Figure 11-2.—PMS/SMS maintenance documentation.

and correct system level faults. Second, they are used to isolate faults to an individual equipment level (such as the FCS computer, FCS radar, or the GMLS). The basic types of system troubleshooting documents are listed below.

1. Test fault directories
2. Indicator fault/system function directories
3. Fault logic diagrams/troubleshooting logic charts
4. System functional diagrams

Test Fault Directories

Fault isolation procedures begin when a system maintenance test (SMT) or a system operation fails. If an SMT fails, test fault directories should be the first troubleshooting documents consulted. A sample test fault directory for a DSOT MRC was illustrated in chapter 9. (Refer to figure 9-17.)

For each step of a DSOT (or SMT) where a fault could occur, a direct reference is made to an appropriate troubleshooting document. You then use the fault logic diagrams (FLDs) and/or system functional diagrams (SFDs) to isolate the test problem. Note that the test fault directory only "directs" you to other troubleshooting references.

Indicator Fault Directories

When a system operation fails, an incorrect indication normally is given on a control panel/console. The indication may be displayed by status lamps, meters, dials, or a combination of such devices. In these situations, fault isolation procedures usually begin by consulting an indicator fault or system function directory.

A sample indicator fault directory is illustrated in figure 11-3. Its format and purpose are similar

EQUIPMENT/INDICATOR	FLDs		SFDs	
	PART	FIGURE	PART	FIGURE
RADAR CONSOLE (Cont.)				
SURFACE TRACK Lamp (GREEN/YELLOW)			4	11-1.22
			7	11-2.22
TDT DESIG Lamp			3	11-1.13
			6	11-2.13
TELEVISION ON Lamp			5	11-1.40
			8	11-2.40
TELEVISION OFF Lamp			5	11-1.40
			8	11-2.40
TRACK ALARM Lamp	1	10-2.10	4	11-1.22
	1	10-2.10	7	11-2.22
WDE DESIG Lamp	1	10-2.5	3	11-1.13
	1	10-2.5	6	11-2.13
1X MAGNIFICATION Lamp			5	11-1.40
			8	11-2.40
5X MAGNIFICATION Lamp			5	11-1.40
			8	11-2.40

Figure 11-3.—Indicator fault directory.

to that of a test fault directory. Our particular example shows an alphabetical listing of the indicator lamps on a radar console. When an operational fault occurs, you would locate the status lamp in question on the directory. Appropriate references to the FLDs and SFDs are given and you would use the procedures in these documents to isolate the problem. If applicable, an indicator fault directory also can refer you to an SMT procedure. Performing the SMT will help determine (or isolate) the fault.

Fault Logic Diagrams

Fault logic diagrams (FLDs) or troubleshooting logic charts (TLCs) are used to speed the system troubleshooting process. The format of an FLD (figure 11-4) requires you to answer a series of branching questions about an observed problem. The questions are brief, to the point, and permit yes or no answers only.

Generally, FLD questions are directed to the status of external indicators (e.g., lamps) or observed equipment conditions/reactions. Depending upon the fault, the status of internal indicators at key test points can be questioned too. The FLD uses a logical process of elimination to guide the technician to the probable trouble area quickly. At this point, the appropriate system or equipment level troubleshooting documents needed to isolate the fault are identified.

System Functional Diagrams

System functional diagrams (SFDs) serve several purposes and can be used to study, analyze, and isolate system faults. A sample SFD is illustrated in figure 11-5.

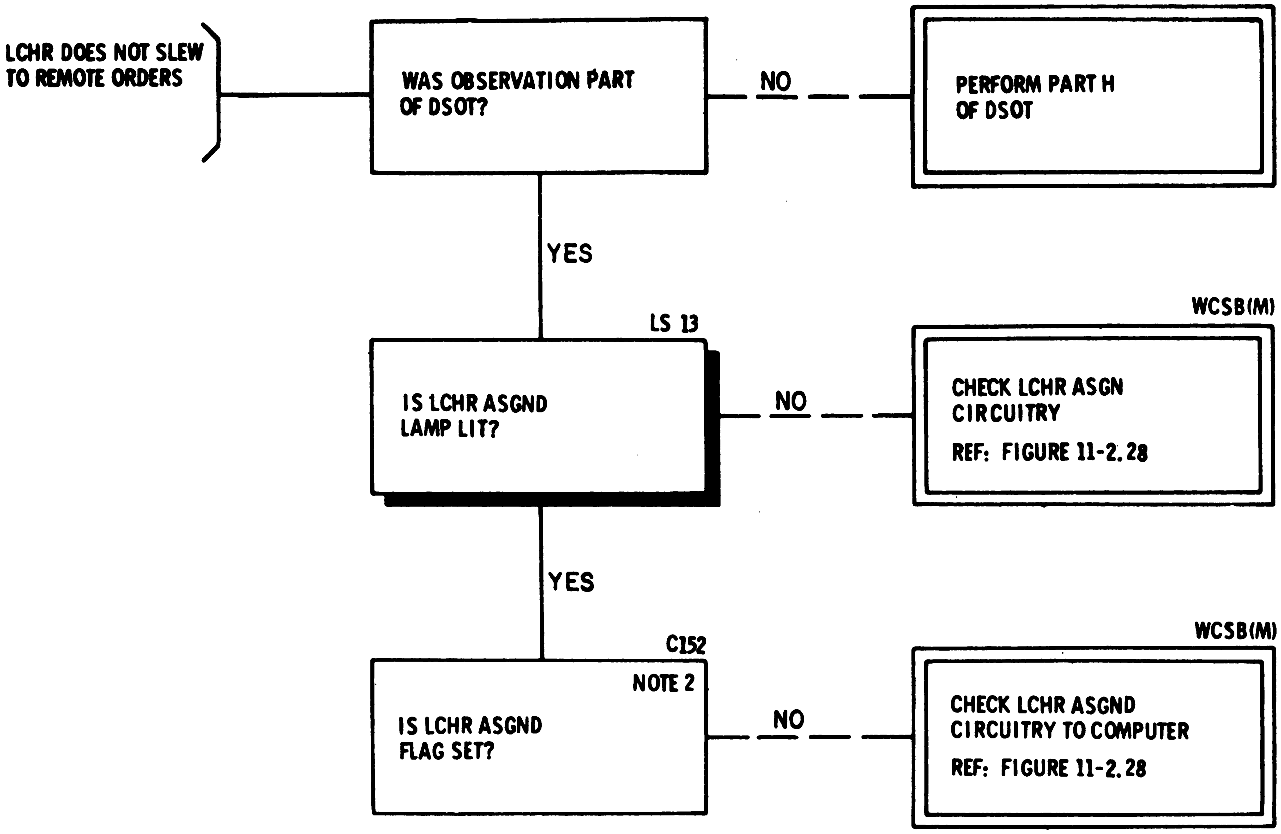


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Figure 11-4.—Fault logic diagram.

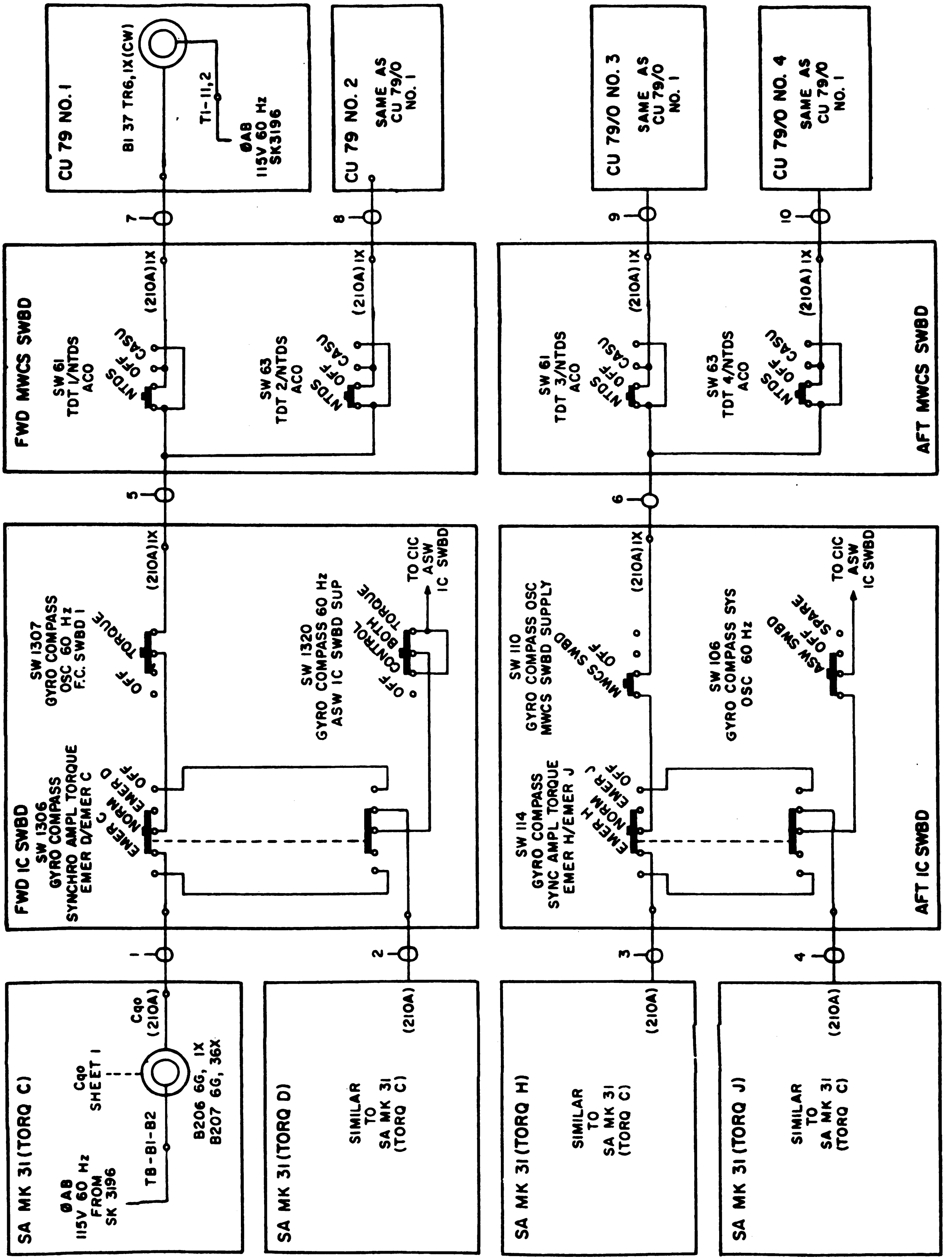

Figure 11-5.—System functional diagram.

An SFD is drawn in a functional flow format or style. The "flow" begins with an input (on the left) and ends with an output (on the right). In between, major circuits, various test points, and specific equipment level components in the signal's path are identified. All the information necessary to understand and troubleshoot a particular mode or phase of system operation is given.

As system troubleshooting aids, SFDs are quite useful documents. However, a certain amount of technical skill is required to interpret an SFD properly. You must be familiar with the system's capabilities and different operational modes. You also must have a basic understanding of the individual equipments concerned.

Fault directories, FLDs, and SFDs are designed to help weapons system personnel find the cause of a problem. If the trouble is isolated to the system level, system maintenance documentation is used to correct the fault. These documents outline the procedures necessary to realign the system and verify its operational readiness. If the trouble is isolated to an equipment level, the equipment's troubleshooting and maintenance documentation must be consulted. In our situation, that means you must use GMLS troubleshooting documents—our next subject.

GMLS TROUBLESHOOTING DOCUMENTS

GMLS maintenance documentation (figure 11-2, right side) also applies to four functional periods. Those periods include (1) scheduled maintenance (SMTs and equipment level MRCs), (2) operation, (3) fault isolation, (4) fault correction. GMLS troubleshooting documents are designed to help you isolate a fault to the lowest replaceable item/component in the equipment. Once the problem is isolated, unscheduled maintenance requirements cards (UMRCs) are used (if necessary) to correct the casualty.

Fault isolation at the GMLS equipment level begins when one of the following conditions occurs.

- A system maintenance test fails.
- A weapons system fault is isolated to the GMLS equipment.
- A GMLS operation fails.
- A maintenance turn-on procedure or step fails.
- An equipment level MRC reveals a problem.

The basic types of GMLS troubleshooting documents and their location within a typical GMLS OP are listed below.

1. Supporting maintenance data—Chapter 5: "Trouble Isolation"
2. Summary signal flow diagrams (SSFDs)—Chapter 5: "Trouble Isolation"
3. Fault isolation tables—Chapter 5: "Trouble Isolation"
4. Reference diagrams—Chapter 6: "Reference Diagrams

Supporting Maintenance Data

Supporting maintenance data includes such items as a list of abbreviations, a troubleshooting index, and a maintenance turn-on (MTO) procedure. Generally, this information is presented in a table format. The purpose of the data is to help you operate and maintain the GMLS.

The list of abbreviations, for example, is especially useful for anyone unfamiliar with the GMLS. It contains an alphabetical listing of the common abbreviations and acronyms used throughout the GMLS's troubleshooting documentation.

The troubleshooting index serves two purposes. First, it lists all major GMLS operations in alphabetical order. Second, it refers each operation to a specific SSFD, fault isolation table, and/or reference diagram. Functionally, a troubleshooting index (figure 11-6) is similar to a weapons system's fault directory. The index helps you to locate other troubleshooting references quickly. In our example, four different references are identified regarding troubleshooting an elevation power drive problem.

The maintenance turn-on (MTO) procedure (figure 11-7) serves several purposes. It lists, in numerical sequence, the specific steps/actions necessary to activate (turn on) the GMLS. It also

Operation	Summary signal flow diagram	Fault isolation table	Electric schematic	Hydraulic schematic
Elevation (SSFD)	5-11	---	---	---
Elevation motor start/run	5-6	5-14	6-5	6-48
Elevation pointing cutout	5-11	---	6-5	6-48
Elevation position order	5-11	5-49	6-6	6-48
Elevation remote order	5-11	5-50	6-6	6-48

Figure 11-6.—Troubleshooting index.

Step	Procedure	Observation	Reference
1	Position 440-vac, 3-phase, 60-Hz POWER TRANSFER DEVICE to NORMAL	At EP1, verify the three 440 VOLTS POWER ON lamps are on	Figure 6-2, sh 1, A2
2	At EP1, position CONTROL SYSTEM circuit breaker CBZ1 to ON	a. Verify the three 115 VOLTS CONTROL POWER ON lamps are on b. Verify the three 120 VOLTS WARM-UP POWER ON lamps are on	Figure 6-2, sh 1, A2 Figure 6-2, sh 1, A4
3	Position remaining EP1 circuit breakers to ON:		

Figure 11-7.—Maintenance turn-on procedure.

identifies the proper indication(s) to be observed after each step in the MTO procedure. Finally it provides a troubleshooting reference for each step. Should a fault occur during the MTO procedure, you can quickly identify the appropriate troubleshooting documents applicable to that problem.

Summary Signal Flow Diagrams

The operation of a (typical) GMLS can be divided into nine basic functions. Those functions include activation, operation selection, missile selection, load, train, elevation, missile firing, unload, and dud jettisoning. Summary signal flow diagrams (SSFDs) show the sequence of events necessary to complete each GMLS function. As a troubleshooting document, you use an SSFD to help isolate operational faults and as a directory to other troubleshooting references.

Figure 11-8 illustrates a small portion of an actual SSFD. Our example comes from the load SSFD of a Mk 10 GMLS. Only three events, or steps, of the entire loading sequence are shown.

An SSFD is fairly easy to interpret and is read from left to right. All equipment events performed during a function are shown in their order or sequence of completion (from first to last). The top half of the diagram identifies the events required for an automatic control sequence. The bottom half of the diagram identifies the events required for a step control sequence (if applicable).

The rectangular boxes on the SSFD are known as operation blocks. Each operation block contains an event title and identifies the applicable fault isolation table reference. Operation blocks are shown one above the other if (1) their events occur at the same time, or (2) there is no specific sequence to their (event) activation.

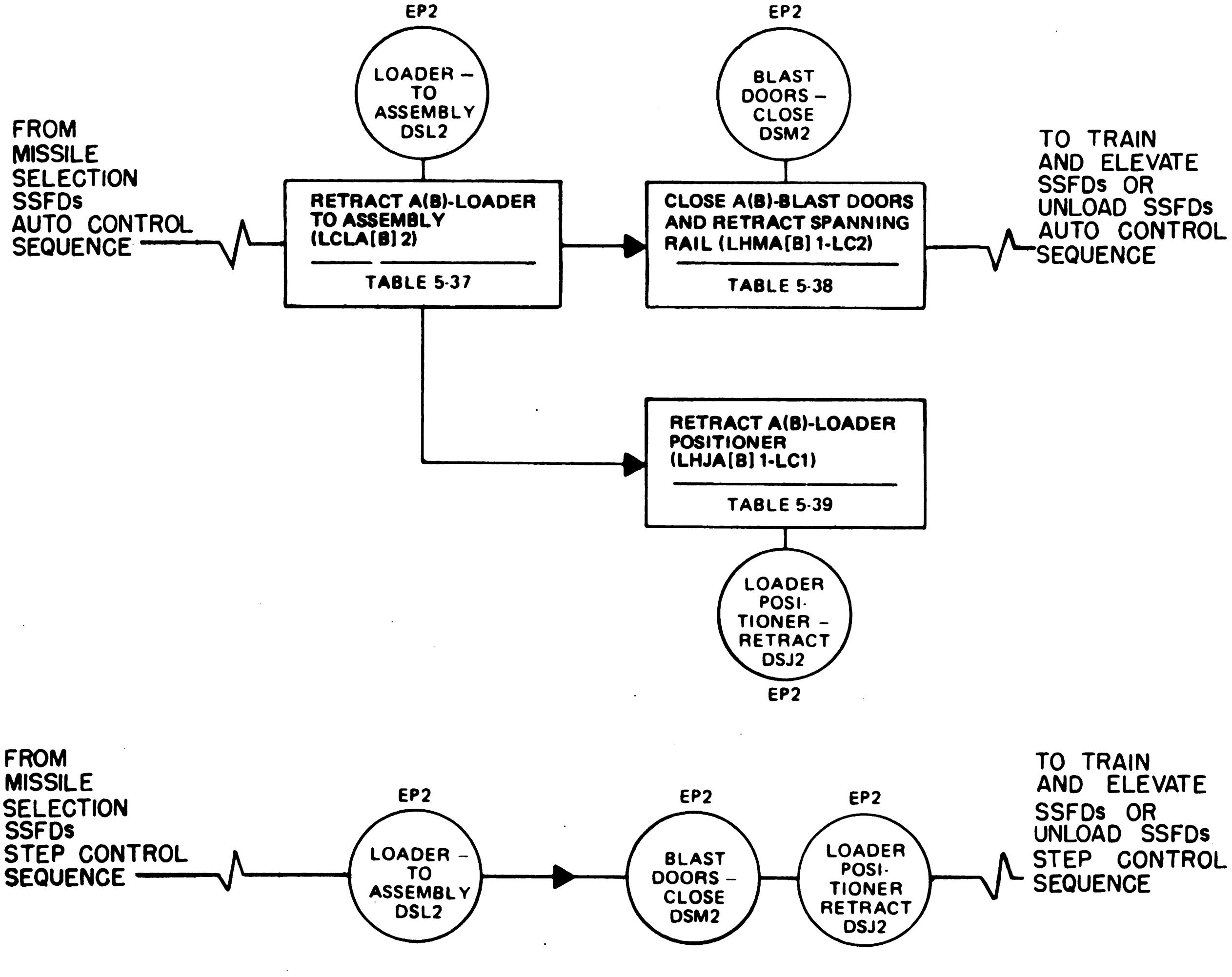
EP2
LOADER – TO ASSEMBLY DSL2
EP2
BLAST DOORS – CLOSE DSM2
FROM MISSILE SELECTION SSFDs AUTO CONTROL SEQUENCE
RETRACT A(B)-LOADER TO ASSEMBLY (LCLA[B] 2)
TABLE 5-37
CLOSE A(B)-BLAST DOORS AND RETRACT SPANNING RAIL (LHMA[B] 1-LC2)
TABLE 5-38
TO TRAIN AND ELEVATE SSFDs OR UNLOAD SSFDs AUTO CONTROL SEQUENCE
RETRACT A(B)-LOADER POSITIONER (LHJA[B] 1-LC1)
TABLE 5-39
LOADER POSI-TIONER – RETRACT DSJ2
EP2
FROM MISSILE SELECTION SSFDs STEP CONTROL SEQUENCE
EP2
LOADER – TO ASSEMBLY DSL2
EP2
BLAST DOORS – CLOSE DSM2
EP2
LOADER POSI-TIONER RETRACT DSJ2
TO TRAIN AND ELEVATE SSFDs OR UNLOAD SSFDs STEP CONTROL SEQUENCE

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Figure 11-8.—Summary signal flow diagram.

The circles on the SSFD are known as "quick-look" indicators. They represent the (lamp) indications that should be displayed when an event is completed. Normally, there is a quick-look indicator associated with each operation block.

Fault Isolation Tables

Fault isolation tables give detailed, step-by-step procedures necessary to isolate equipment malfunctions. There are two types of fault isolation tables—operation and component. Operation tables give fault isolation data related to major output functions or operations. Component tables give fault isolation data concerning individual control relays or other key circuit components. Both types of tables are illustrated in an identical format.

General notes and warnings that apply to all fault isolation table procedures are listed at the beginning of the trouble isolation chapter. Additionally, each table lists its own specific notes. That information usually includes any special warnings, required test equipment, associated reference diagrams, and so forth.

A sample component fault isolation table is shown in figure 11-9. Take a moment to review the information in the figure. Fault isolation tables are fairly easy to interpret. They list each troubleshooting step to be done in a numeric sequence. Essentially, these steps tell you exactly what to do and what to check. Voltage tests are generally used to isolate the fault to a major section or circuit area.

Each test procedure also lists the action to take for a positive or negative test result. You may be referred to other troubleshooting documents or directed to make another test. Continuity tests often are used to isolate the fault to a specific component.

Fault isolation tables are the basic troubleshooting documents for a GMLS. Their step-by-step procedures provide a complete and logical sequence for isolating almost every type of equipment problem. We highly recommend that you know where these tables are located and become familiar with their information. However, fault isolation tables are mainly designed for personnel who are familiar with the equipment and should be used in the initial stages of the troubleshooting process. You will use the GMLS's reference diagrams as your primary troubleshooting documents.

REFERENCE DIAGRAMS

The reference diagrams and related listings for a "typical" GMLS include the following documents:

1. Component listings
2. Electrical schematic diagrams
3. Hydraulic schematic diagrams
4. Internal wiring diagrams
5. Interconnection cabling information
6. Cable listings

Generally, these documents are located within the trouble isolation chapter (chapter 6) of the GMLS's OP. However, some of the systems have their internal wiring diagrams and cable listings reproduced on microfilm. If your system's documentation is set up that way, you have two extra responsibilities. First, you should know where your microfilm files are located. Second, you must know how to retrieve/obtain the information from the microfilm.

Component Listings

The component listing (figure 11-10) is an index for the GMLS's control system. The various electrical components of the system are listed in alphanumeric order by reference designation. The component listing gives the function, part number, and equipment location of each component. It also identifies the electric schematic diagram on which the component appears.

Electric Schematic Diagrams

Electric schematic diagrams are the most frequently used troubleshooting documents of the

Specific Notes

A. WARNING: Voltages dangerous to life exist when equipment is open and energized.

B. Prerequisite condition:
At EP2, KCOA(B)2 is not energized.

C. Reference figure:
1. Figure 6-10. A- and B-Relay Circuits
2. Figure 6-36. Sequence and Ready Lamps

Step	Indicator	Condition	Test	Result	Action
1	At EP4(5), verify WING & FIN ASSEMBLERS CLEAR lamp	On	---	---	See Step 2
		Off	At EP2, verify KCOA(B)1 energizes when the four footswitches are pressed	Yes	1. Check lamp DSOA(B)1 circuit See figure 6-36, sh 1, B1 2. See step 2
				No	See table 5-154
2	---	---	1. Press the four footswitches and position SMOA(B)2 at EP4(5) to ASSEMBLED 2. Check 117 vac between EP2-23-2 & -30-13 (EP2-123-2 & -130-13)	Yes	1. At relay test unit, check KCOA(B)2 coil 2. Check continuity between: ● EP2-23-2 & KCOA2-C1 (EP2-123-2 & KCOB2-C1) ● KCOA2-C2 & EP2-30-13 (KCOB2-C2 & EP2-130-13)
				No	1. At EP4(5), position SMOA(B)2 to ASSEMBLED 2. Check continuity between EP2-18-11 & -23-2 (EP2-118-11 & -123-2) thru SMOA(B)2-16,17 See figure 6-10, sh 3 (sh 7), B3

Figure 11-9.—Fault isolation table.

Designation	Function	Part number	Location	Figure, sheet, and zone
LC—solenoid, control or LH—solenoid housing—continued				
LHPA1-LC1 (LHPB1-LC1)	Retract launcher aft-shoe latch	1593073	Guide arm	6-26, 1, B2 (6-26, 2, B2)
LHPA1-LC2 (LHPB1-LC2)	Extend launcher aft-shoe latch	1593073	Guide arm	6-26, 1, B1 (6-26, 2, B1)
LHRA1-LC2 (LHRB1-LC2)	Extend launcher contactor	1593073	Guide arm	6-27, 1, B1 (6-27, 2, B1)
LHRA1-LC3 (LHRB1-LC3)	Retract detent for LC2	1593073	Guide arm	6-27, 1, B2 6-27, 2, B2)

Figure 11-10.—Component listing.

GMLS reference diagrams. These diagrams show the functional arrangement of a circuit and are drawn so signal paths can be traced easily. Electric schematic diagrams are prepared for every major and minor power and interlock control circuit in the GMLS.

Several electric schematic diagrams have been discussed throughout this manual. (Refer to figures 4-29, 4-30, and 6-12 for examples.) Standard electrical symbols, reference designations, and nomenclature were used to identify each circuit component. Various connection or test points also were specified. Unless otherwise noted, all components are shown in their normally deenergized state or condition. Each circuit can be divided into primary and secondary signal paths for the different modes of operation.

An actual (unmodified) electrical schematic diagram is shown in figure 11-11. This type of drawing is sometimes known as an elementary wiring or relay ladder diagram (print). Within the GMLS OP, the schematic is identified by an assigned figure number and title. Continuation sheets of a figure are listed as sheet 2 of 2, sheet 17 of 34, and so on. The manufacturer's drawing number is printed in the lower right-hand corner of the page. The circuit is surrounded by border lines, which are marked off into zones. (Letters divide the diagram horizontally; numbers divide the diagram vertically.) The zones (A1, B2, and so forth) are used as location references for key circuit components. For example, in figure 11-11, solenoid LHRB1-LC2 is found on (the OP's) figure 6-27, sheet 2, zone B1 (6-27 2, B1).

Another type of electric schematic diagram can be seen if you refer to figure 4-65. This type of electric schematic is used by the "newer" GMLSs that have solid-state control circuitry. Discrete electronic components, basic ICs, special purpose ICs, and the like are used in those circuits. Logic symbols represent how a circuit functions with respect to specific input and output operations.

Take a moment to compare the "conventional" and "newer" electric schematic diagrams shown in figures 11-11 and 4-65 respectively. How are they different? How are they similar? Obviously, the main difference is in the symbology used to represent the circuit components. Functionally, however, both diagrams are identical in purpose.

Besides diagramming the complete functional operation of a circuit, electric schematic diagrams contain a wealth of troubleshooting information. We have made the point before, but it is worth repeating. It is absolutely essential you understand the electric schematic diagrams of your GMLS. Learn where they are located and know how to

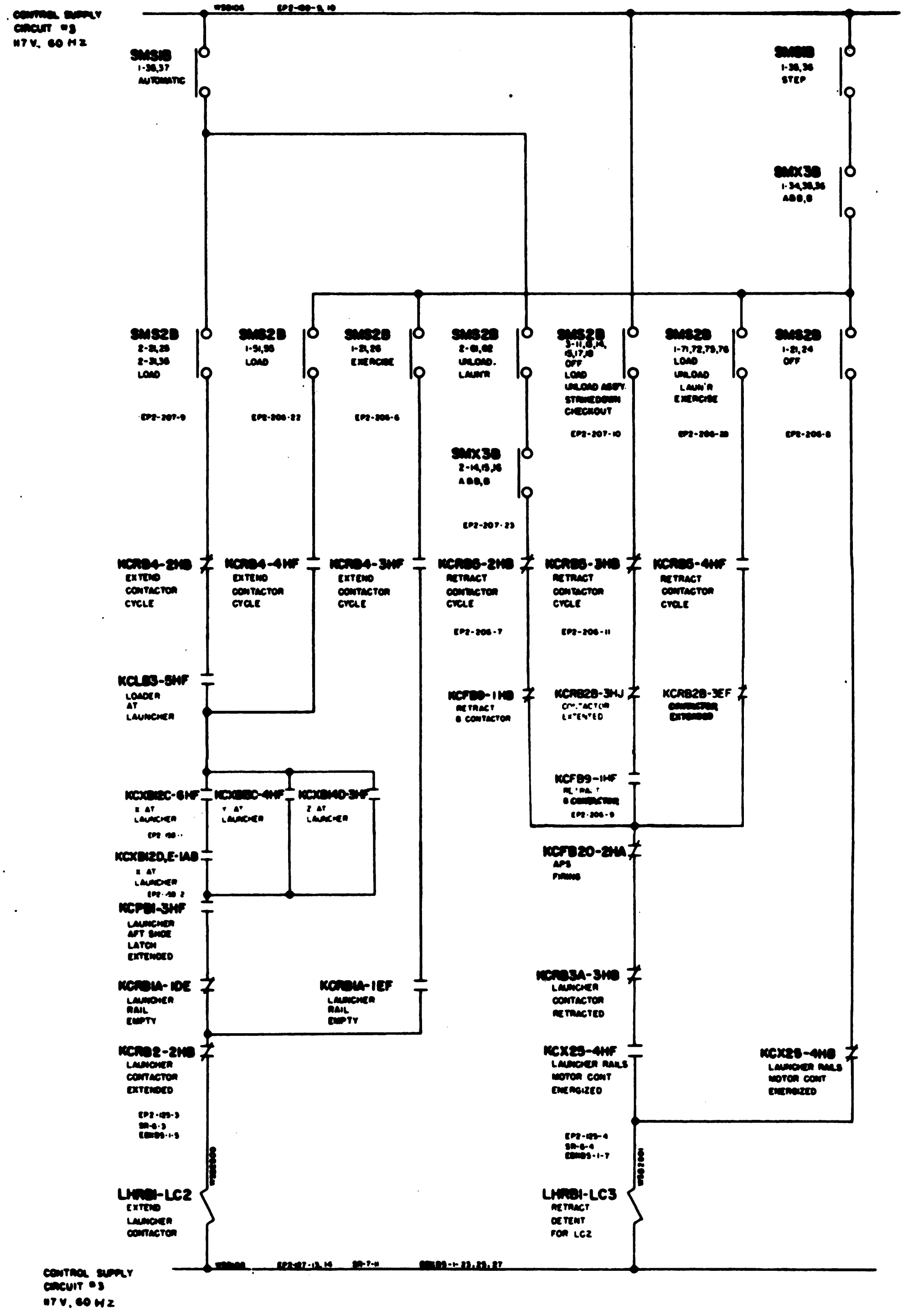

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Figure 11-11.—Electric schematic diagram.

use them correctly. You will be a much better troubleshooter if you follow this advice.

Hydraulic Schematic Diagrams

Hydraulic schematic diagrams illustrate the hydraulic, pneumatic, and mechanical components of a GMLS. They are intended to help you understand the physical arrangement and functional operation of the system.

Hydraulic schematic diagrams usually appear twice within a GMLS OP. They are first encountered in the physical and functional description chapter of volume 1. These diagrams primarily are designed to orient and train personnel on the equipment. A write-up in the text accompanies each diagram. It explains how a small group of related components function during a specific operation (e.g., an extend cycle or a retract cycle). Generally, these diagrams use a color code to represent different hydraulic and pneumatic operating pressures. Several volume 1-style hydraulic schematic diagrams have been used throughout this text. Refer to figures 5-14, -16, -17, -27, -28, and -34 for examples.

The second time hydraulic schematic diagrams are found in a GMLS OP is in the trouble isolation chapter of volume 2. These reference diagrams are slightly different from those presented in volume 1. One reason is they are troubleshooting documents rather than training aids. Generally, these schematics depict entire hydraulic/pneumatic systems and do not illustrate individual functions or cycles. Also, they are reproduced in black and white and use reference designations (such as P1, P2, T1, and so forth) to identify various operating pressures.

Hydraulic schematic diagrams are very useful (and essential) troubleshooting references. They are often used with the electric schematic diagrams to isolate a problem. You will find it helpful to consult both volume 1- and volume 2-style diagrams during troubleshooting procedures.

Internal Wiring Diagrams

Internal wiring diagrams show the point-to-point wiring connections INSIDE an electrical panel, connection box, solenoid housing, and so forth. These diagrams are very useful troubleshooting documents and can serve several purposes.

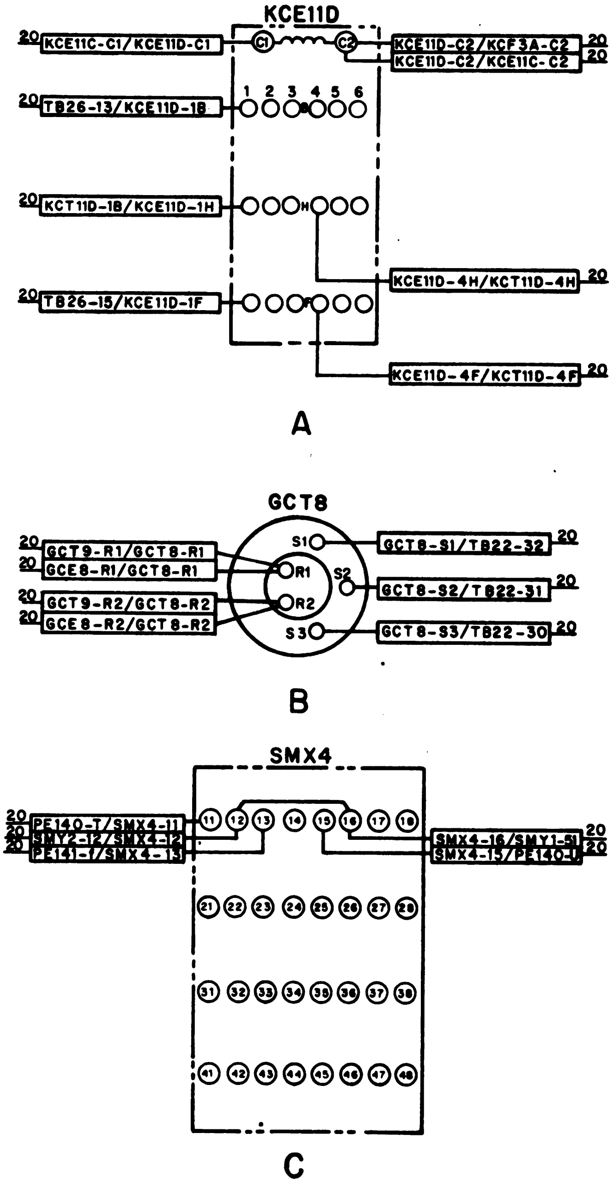

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Figure 11-12.—Internal wiring diagrams.

Figure 11-12 illustrates how three common electrical components appear on a typical internal wiring diagram. Each line drawn to a component's connection point represents a single wire. Each wire is identified with two standard reference designations (e.g., KCE11-C1/KCE11D-C1). (Note: We will refer to those designations as cable marker information.) The designations identify the termination points for either end of the cable. (Similar information is reprinted on the wire's cable marker, or spaghetti.)

In troubleshooting, it is often necessary to follow or trace a signal's path as it runs from component to component. An internal wiring diagram is especially useful for that task. You simply read the cable marker information to find where the next connection point is located. However, you must remember to be careful when switch or relay contacts are part of the signal's path.

For example, refer to view A of figure 11-12. Note the cable marker information on the 4H and 4F contacts of the miniature plug-in control relay. (This type of relay also was illustrated in figure 4-15.) Let's assume we are tracing a signal that starts at KCT11D-4H. Cable marker data informs us the next connection point is at KCE11D-4H. The internal wiring diagram of KCE11D (view A) supports that fact. But where does the signal go from the KCE11D-4H point?

To answer that question, you must recall how this type of relay operates. In a deenergized state, the HB contacts are normally closed, while the HF contacts are normally open. After the relay energizes, the HB contacts open and the HF contacts close. The signal path we are tracing will be continued to KCE11D-4F only when the relay is energized. From KCE11D-4F, the signal proceeds to KCT11D-4F. If the relay is deenergized, the open 4HF contacts of KCE11D will interrupt the circuit. The same principle applies to switch contacts. As the switch is turned through various positions, opening and closing contacts will interrupt or continue a signal path.

If you know how to use an internal wiring diagram, certain maintenance tasks can be done more easily. For instance, consider the synchro shown in view B of figure 11-12. Let's assume your equipment has a small alignment problem and you have isolated the malfunction to GCT8. To correct the problem you must "zero" that synchro. However, let's also assume that GCT8 is buried deep within the back of the EP2 panel. In short, the synchro is mounted in an awkward location. It will be very difficult to connect test leads to the synchro's stator leads.

Therefore, what we need are connection/test points located closer to the front of the panel. Consult your internal wiring diagrams and look for test points that are easier (and safer) to reach. In our example, the stator leads of GCT8 connect to points on TB22. (Refer to the cable marker data.) If TB22 is easier to reach, you may connect your test leads to the TB points identified on the internal wiring diagram. That technique (or trick) can be used on many components throughout the GMLS.

Internal wiring diagrams are valuable references during certain fault correction procedures too. Let's assume the manually operated switch shown in view C of figure 11-12

Designation	Function	Location	Reference dwg
LHPA1-LC1 (LHPB1-LC1)	Retract launcher aft-shoe latch	Guide arm	1877722
LHPA1-LC2 (LHPB1-LC2)	Extend launcher aft-shoe latch	Guide arm	1877722
LHRA1-LC2 (LHRB1-LC2)	Extend launcher contactor	Guide arm	1877722
LHRA1-LC3 (LHRB1-LC3)	Retract detent for LC2	Guide arm	1877722

Figure 11-13.—Interconnection cabling locating index.

is defective. To repair the casualty, you must replace SMX4 with a new unit. However, before you begin to disconnect the leads from the old switch, we recommend you consult the internal wiring diagrams.

Study the switch's wiring arrangement as shown on the diagram. Then compare that information to the actual wiring arrangement on the switch. In theory, they should be identical; in a few rare cases, they could be different. As you disconnect each lead, compare its cable marker information to the data on the internal wiring diagram. As you reconnect the leads to the new switch, use the internal wiring diagram to double-check your work. That ensures you do not forget any wires, especially the tiny jumper wires found on many switches. (The wire between SMX4-12 and SMX4-16 is such a jumper.)

As you have seen, internal wiring diagrams are versatile and important reference diagrams. Make it a point to understand how they are used on your particular GMLS.

Interconnection Cabling Information

Interconnection cabling information is designed to help you identify and locate electrical components within the GMLS. The information consists of (1) an interconnection cabling locating index and (2) interconnection diagrams.

Figure 11-13 illustrates a typical interconnection cabling locating index. Its format is very similar to that of a component listing described earlier. (Refer to figure 11-10 and compare.) The interconnection cabling locating index is basically a directory. It lists the designation, function, and equipment location of the system's components. Additionally, the index identifies a reference drawing number for each component (e.g. 1877722). That number refers you to an interconnection diagram.

Interconnection diagrams show the external or interconnecting cabling arrangement for each cable in the GMLS. That includes all power distribution, control weapons system, heating, ventilation, and lighting cables. Figure 11-14 illustrates a typical interconnection diagram used by one of the GMLSs. In our example, terminal box EBX4 serves as a central connection point for various interlock switches and solenoids identified on the drawing. In turn, EBX4 is interconnected to the EP2 control console (by WM227).

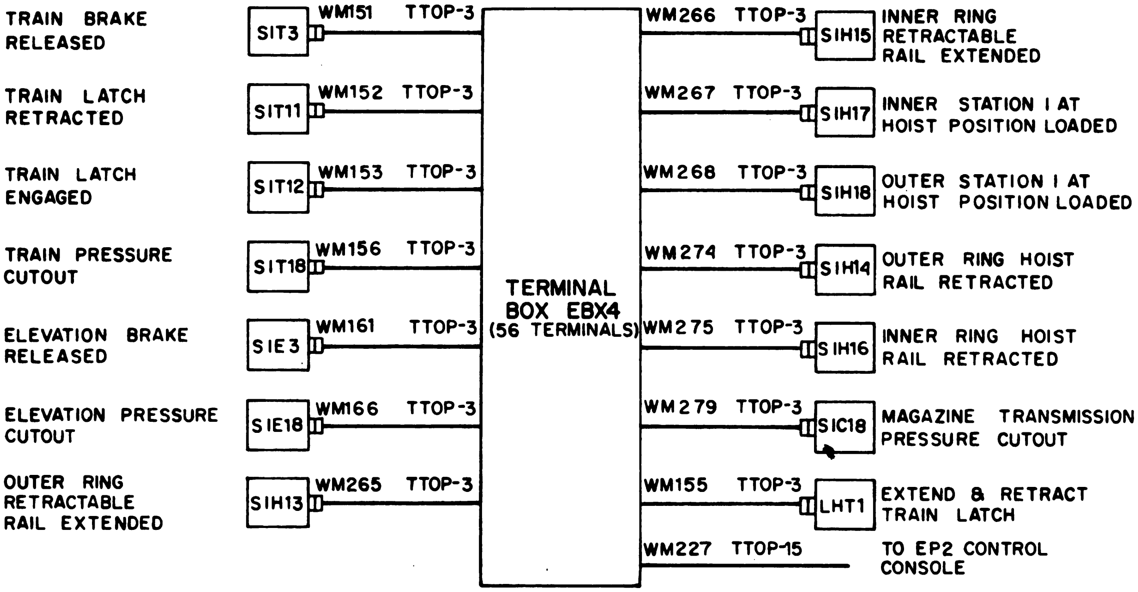

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Figure 11-14.—Interconnection diagrams.

Each cable on the diagram is identified by an assigned multiple cable (WM) number and a Navy cable type number. Several common Navy cable type numbers are "translated" below:

1. TTOP-3—twisted pair, telephone, oil resistant, portable cable with 3 pairs of (or 6 individual) conductors.

2. TTOP-15—same type of cable as above with 15 pairs of (or 30 individual) conductors.

3. MSCA—multiple conductor, silicon insulated, control, armored cable; MSCA-14 has 14 individual conductors, but that number varies.

4. MHOF—multiple conductor, heat and oil resistant, flexible cable; MHOF-37 has 37 individual conductors, but that number varies too.

You will find many other Navy cable type numbers listed on interconnection diagrams. One reference you can consult to interpret these numbers is *Data Pertaining to Electric Shipboard Cable,* NAVSEA 0981-052-8090. The ship's Electrician's Mates (EMs) should have a copy of that (or a similar) handbook.

Cable Listings

Cable listings provide detailed information about each cable in the GMLS. They are useful troubleshooting aids and complement the information found on the system's interconnection diagrams. Cable listing information consists of (1) a cable list index and (2) cable listing data blocks.

Figure 11-15 illustrates a typical cable list index. It is a directory to help you locate the various cable listing data blocks. In it, cables are listed in order by their WM number. The "From unit A" column identifies the component at one end of the cable. The "To unit B" column identifies the component at the other end of the cable. The last column identifies the OP page on which a cable listing data block can be found.

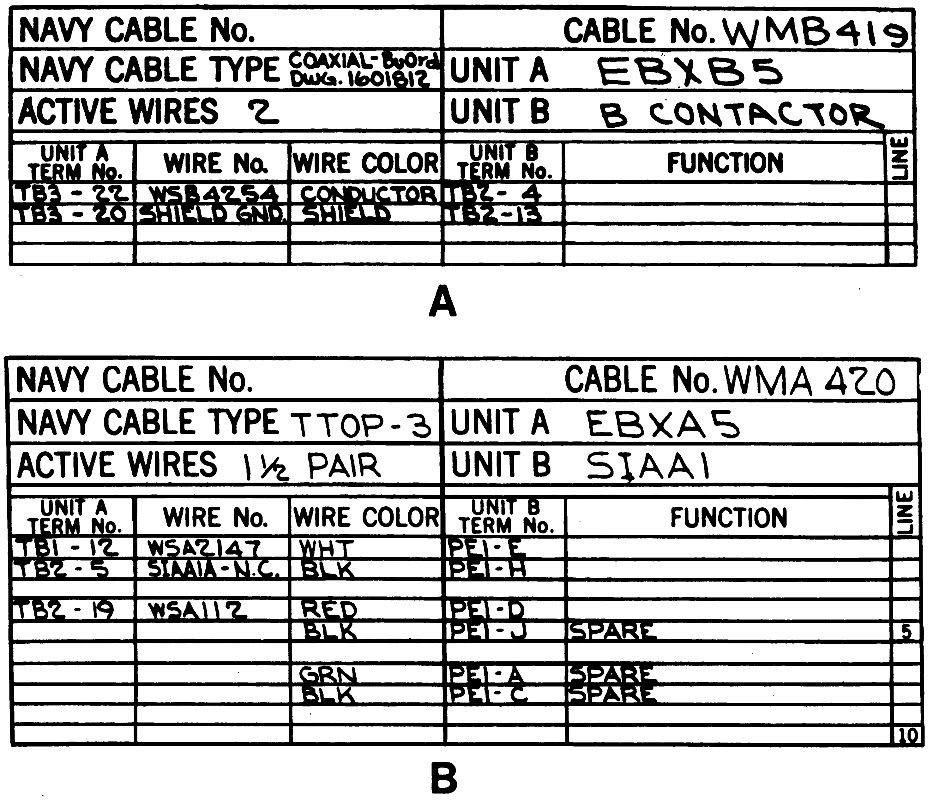
Figure 11-16 illustrates two typical (and simple) cable listing data blocks. Similar information is provided for each cable in the GMLS. Take a moment to study the information presented in our two examples. Cable listings are self-explanatory and quite detailed. About the only information missing is the length of the cable. That data normally can be obtained from the GMLS's Illustrated Parts Breakdown (IPB).

TEST EQUIPMENT

Logically, the next topic after troubleshooting documentation must be test equipment. The two subject areas are closely related. As a maintenance technician, you must be aware of the different forces acting within GMLS circuits. In electric and

Cable No.	From unit A	To unit B	Page No.
WM400 through WM499—arming and firing missile control—continued			
WMA418	EBXA5	A-contactor	6-326
WMB418	EBXB5	B-contactor	6-326
WMA419	EBXA5	A-contactor	6-326
WMB419	EBXB5	B-contactor	6-326
WMA420	EBXA5	SIAA1	6-326
WMB420	EBXB5	SIAB1	6-327
WMA421	EBXA5	SIAA2	6-327
WMB421	EBXB5	SIAB2	6-327

Figure 11-15.—Cable list index.



NAVY CABLE No.

CABLE No. WMB419

NAVY CABLE TYPE COAXIAL-BuOrd DWG. 1601812

UNIT A EBXB5

ACTIVE WIRES 2

UNIT B B CONTACTOR

UNIT A TERM No.	WIRE No.	WIRE COLOR	UNIT B TERM No.	FUNCTION	LINE
TB3 - 22	WSB4254	CONDUCTOR	TB2- 4		
TB3 - 20	SHIELD GND.	SHIELD	TB2-13		

A

NAVY CABLE No.

CABLE No. WMA 420

NAVY CABLE TYPE TTOP-3

UNIT A EBXA5

ACTIVE WIRES 1½ PAIR

UNIT B SIAA1

UNIT A TERM No.	WIRE No.	WIRE COLOR	UNIT B TERM No.	FUNCTION	LINE
TB1 - 12	WSA2147	WHT	PE1-E		
TB2 - 5	SIAA1A-N.C.	BLK	PE1-H		
TB2 - 19	WSA112	RED	PE1-D		
		BLK	PE1-J	SPARE	5
		GRN	PE1-A	SPARE	
		BLK	PE1-C	SPARE	
					10

B

Figure 11-16.—Cable listing data blocks.

electronic circuits, the basic forces we are concerned with are voltage, current, and resistance. Other important forces include inductance, capacitance, frequency, power, and so on. In hydraulic and pneumatic circuits, the basic forces we are concerned with are operating pressure, volume, and so forth.

If you could measure the quantity of a particular force, it would be easier to understand what is happening inside a circuit. You also could determine why a circuit is not doing what it is supposed to do. In short, circuit measurements are an important part of the troubleshooting process. These measurements are taken with devices commonly known as test equipment.

There are many different types of test equipment used throughout the Navy. Our discussion of these troubleshooting tools will be general and limited to the items typically used in ordnance work. The "Trouble Isolation" chapter of your GMLS OP specifies the test equipment required to maintain your system. (Test equipment requirements vary between the GMLSs.)

Basic information about test equipment is presented in (1) NEETS Module 3 and (2) *Basic Electronics,* Volume 1, NAVPERS 10087-C. (As this text was written, NEETS Module 16, *Introduction to Test Equipment,* was being prepared and should be available in the near future.) We highly recommend you consult those references for more information about test equipment.

GENERAL INFORMATION

Before discussing various pieces of test equipment, let's examine some general information concerning these important tools. You would be wise to keep the following points in mind.

Each ship is issued a limited number of general purpose electronic test equipment (GPETE). The actual onboard allowance is established in the Ship Portable Electrical/Electronic Test Equipment Requirements List (SPETERL). Aboard ship, allotted test equipment is divided among the various work centers/groups. To avoid duplication, a share and exchange policy among work centers is encouraged. That ensures each piece of test equipment is used to its fullest extent.

All test equipment should be treated as delicate instruments. You must take extra special care of these expensive and often hard-to-come-by instruments. Meter movements, in particular, are very sensitive. They are easily damaged if they are subjected to rough handling and other abuses. Repeated applications of inputs greater than the selected range of the meter will cause damage. If the meter movement is not completely ruined, at least its accuracy will be affected.

The best piece of test equipment is of NO use to a technician who does not know how to use it. Learn the controls and capabilities of the meter before using it. You also must have an understanding of the circuit being tested.

When measuring/testing electric circuits, do not forget the fundamental rules, laws, and formulas associated with electricity. The four basic electrical quantities are: E = voltage in volts: I = current in amperes: R = resistance in ohms: and P = power in watts. Any single unknown quantity can be determined if you know any two of the other quantities. The formula wheel in figure 11-17 illustrates these relationships.

There are several "laws" worth remembering, and Ohm's law is probably the most important. It states "The current (I) in a circuit is directly proportional to the applied voltage (E) and inversely proportional to the circuit's resistance (R)." Expressed in a mathematical formula, Ohm's law is (1) $I = \frac{E}{R}$, (2) $E = IR$, or (3) $R = \frac{E}{I}$.

Be sure you understand and apply the rules for E, I, R, and P in series and parallel circuits. The rules for a series circuit are summarized below.

1. The voltage drop across a resistor in a series circuit is proportional to the ohmic value of the resistor.

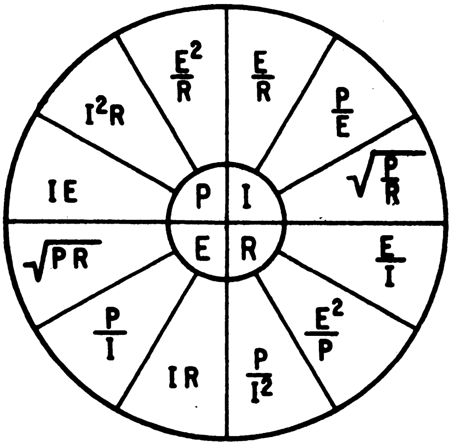


Figure 11-17.—Formula wheel for the four basic electrical quantities.

2. Total voltage across a series circuit is equal to the sum of the individual voltage drops.
3. Current remains the same through each part/component of a series circuit.
4. Total resistance in a series circuit is equal to the sum of the individual resistances.
5. Total power in a series circuit is equal to the sum of the amount of power used by each circuit component.

The rules for E, I, R, and P in a parallel circuit are summarized below.

1. The current through any branch of a parallel circuit is inversely proportional to the amount of resistance of a branch. (In other words, source current divides among the available circuit paths.)
2. Total current in a parallel circuit is equal to the sums of the currents in the individual branches.
3. Voltage remains the same across each branch of a parallel circuit and is equal to source voltage.
4. The total resistance of a parallel circuit is smaller (or less) than the smallest resistance. The formula used to express total resistance in a parallel circuit is

$$R+ = \frac{R1 \times R2}{R1 + R2}.$$

5. Total power in a parallel circuit is equal to the sum of the individual power used by each circuit component. (That rule is identical to the total power rule for a series circuit.)

METERS

The most common types of test equipment use some kind of metering device to measure an electrical quantity. These instruments are called meters, and the "metering device" is commonly referred to as a meter movement. The meter movement reacts to an electrical force and moves a pointer (needle) across the meter's scale. A popular movement is the D'Arsonval type of meter movement.

Meters, in general, can be divided into two basic categories—in-circuit and out-of-circuit. In-circuit meters are an installed part of a panel or unit. These meters are connected to one or more critical or representative circuits within the panel. In-circuit meters monitor the operation of the unit and can be used during troubleshooting procedures. In-circuit meters are frequently referred to as built-in test equipment. The milliammeters on the front of a magnetic amplifier and an ESCU are two examples of in-circuit meters. (Refer to figures 6-16 and 6-21.)

In troubleshooting, it is often necessary to connect a meter to various test points throughout a GMLS. In-circuit meters are at a disadvantage because they cannot be moved. Out-of-circuit meters are fully self-contained instruments. They use low voltage d.c. batteries as a source of power. Other types of out-of-circuit meters must be connected to a 115-volt a.c. power source. Although "plug-in" meters are less mobile, they are still considered portable test equipment.

In troubleshooting GMLS problems, we are primarily concerned with measuring voltage, resistance, and (in some situations) current. You could use a voltmeter to measure voltage, an ohmmeter to measure resistance, and an ammeter to measure current. Individual meters such as those mentioned above do exist, but you probably will not use them. Your number one piece of test equipment will be a multimeter.

Multimeters

A multimeter is the most common measuring device/test equipment used in the Navy. Functionally, a "multiple meter" is a d.c. ammeter, an a.c. ammeter, a d.c. voltmeter, an a.c. voltmeter, and an ohmmeter. All those capabilities are contained within a single, portable case. Your work center should have one, and preferably two, multimeters on hand.

The front view of a typical multimeter is illustrated in figure 11-18. Our example is known as a Simpson 260 model multimeter. Another common multimeter manufactured by Simpson is designated AN/PSM-4B. Both meters are very similar and if you know how to use one, you can use the other.

The front of a multimeter may look complicated, but it is quite easy to operate. Most multimeters use a D'Arsonval meter movement

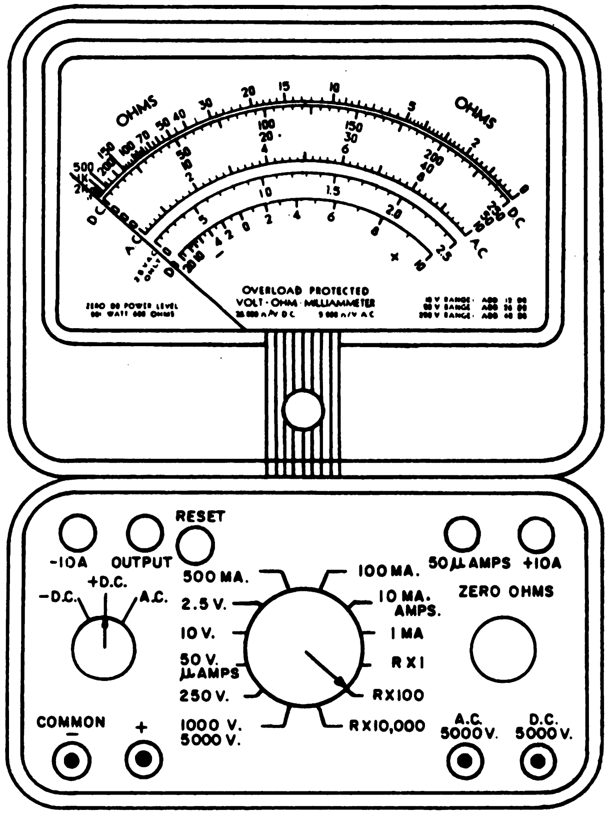


Figure 11-18.—A typical multimeter.

and have a built-in rectifier for a.c. measurements. The Simpson 260 multimeter has a 9-volt d.c. battery as a power source for measuring resistance values. The AN/PSM-4B uses a 22.5-volt d.c. battery for the same purpose. When solid-state circuits are being tested, the Simpson 260 is preferred. Its lower power source will not damage the voltage-sensitive solid-state components.

METER LEADS AND TEST JACKS.—Two meter leads are furnished with the multimeter. When not in use, they are stored in a small compartment inside the case. Both meter leads are interchangeable and will fit (plug) into any of the test jacks on the meter's front panel.

Normally, one meter lead is black and the other is red. The color coding is used to help avoid confusion when measuring polarity sensitive quantities. Usually, the black lead is assigned the negative potential or common; the red lead is assigned the positive potential.

The multimeter has eight jacks, two in each corner of the front panel. The meter leads are plugged into the proper jacks to obtain the circuit and range desired for each application. The common or − (negative) and + (positive) jacks are the most frequently used jacks on the meter. The black meter lead is connected to the common jack for all circuits and ranges except when measuring 10 amperes d.c. The red meter lead is connected to the + jack for all circuits and ranges except those designated by the special function jacks.

The several special function jacks are clearly labeled and self-explanatory. The output jack is used when you are measuring an a.c. voltage component that is superimposed on a d.c. value. (The a.c. component is commonly known as "ripple.")

The function switch of the multimeter has three positions: −D.C., +D.C., and A.C. These positions select the d.c. or a.c. (rectifier) function and change the polarity of the d.c. function. To measure resistance, set the function switch to the +D.C. position.

The zero ohms switch is an adjustable resistor used to set the 0 ohms reading for resistance measurements.

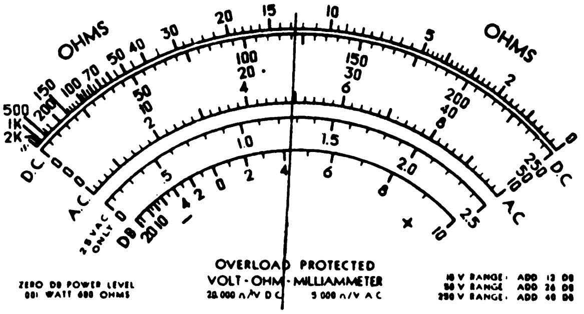
The reset button is connected to a circuit breaker inside the meter. The circuit breaker protects the meter movement from overload conditions. If the breaker trips, the reset button pops up. You must depress it to reset the meter. Not all multimeters have this form of protection. In many cases, a fuse (inside the meter) is used instead.

When the multimeter is not in use, disconnect the test leads and store them properly in the case. Turn the range switch to the highest voltage scale. Set the function switch to the A.C. position. These simple precautions are intended to protect the meter. If the next person using the meter fails to check the range and function switches, the meter could be damaged if applied to a high power circuit.

SCALES.—The biggest trick to using a multimeter is in interpreting the various scale readings correctly. It is not that hard a task, but does take a bit of practice to do well. Figure 11-19 illustrates a multimeter scale with its pointer about mid-scale. Use the chart below the figure to practice interpreting various readings.

The scales of the multimeter are divided into five separate lines. The top line (scale) is used when you are measuring resistance on any range multiplication factor ($R \times 1$, $R \times 100$, and so forth). If the multimeter in figure 11-19 were set on the $R \times 1$ range, the reading would be about 12.7 ohms. The second line is used for d.c. voltage and current measurements. The third line is used for a.c. voltage and current measurements. The numbers between these two scales are used with both d.c. and a.c. functions. Did you notice there is a difference between the d.c. and a.c. scales? That is because the a.c. scale (graduations) must indicate effective a.c. quantities.

The fifth (bottom) line is labeled the DB scale. It is used when the multimeter is set for the OUTPUT function.



FUNCTION SWITCH	-D.C./+D.C. A.C.	INDICATION
5000 V	+ d.c.	+2420.00Vd.c.
1000 V	− d.c.	− 484.00Vd.c.
250 V	+d.c.	+ 121.00Vd.c.
50 V	a.c.	24.90Va.c.
10 V	a.c.	4.99Va.c.
2.5 V	a.c.	1.28 Va.c.
10 A	+d.c.	4.82 Ad.c.
500 mA	a.c.	249.00mAa.c.
100mA	a.c.	49.90mAa.c.
10mA	+d.c.	4.84mAd.c.
50μA	+d.c.	24.20μAd.c.
R x 100	+ d.c.	1.27 kΩ

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Figure 11-19.—A multimeter scale and readings.

Most multimeters (and some of the other meters) have a mirror built into their scale (figure 11-20). The mirror helps to reduce "parallax error" when you are reading the scale. Parallax error is introduced into a reading when you view the meter's scale from an angle. If possible, always view the meter's scale straight on.

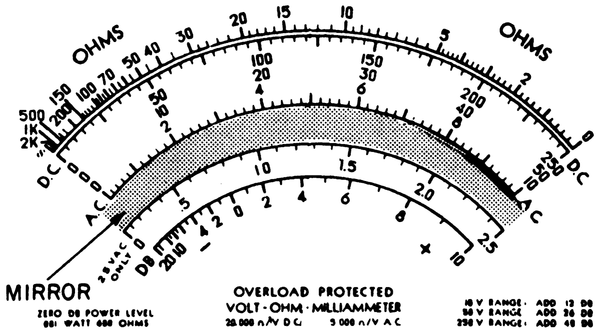

Figure 11-20.—A multimeter scale with a mirror to reduce the parallax problem.

As you can see, a multimeter is a very versatile piece of test equipment. We recommend you become familiar with its operation and capabilities. Above all, take care of your multimeter. Handle it carefully, turn it in for calibration on time, and keep it well maintained.

Digital Multimeters

In keeping pace with the state of the art, digital-style test equipments are becoming more popular. Their primary advantage is that they are easier to read because interpolation is not required. Conventional meters, such as the Simpson 260, are good, reliable pieces of test equipment. However, very low and sensitive values cannot be measured accurately with a meter movement.

Because of their accuracy, digital meters are preferred when you are working with solid-state circuitry. Logic level voltages are extremely sensitive and power supply output adjustments are very critical. Tolerances are often with tenths, and even hundredths, of a volt. Digital meters permit such precise adjustments/measurements.

Functionally, digital and conventional meters are quite similar. If you can use one, you can easily master the operation of the other. Two typical digital multimeters used in GMLS work are illustrated in figure 11-21. View A shows a meter designated 8600A-01 (SCAT 4212) (used by the Mk 10 and Mk 26 GMLS). View B shows a meter designated 8800A (SCAT 4211) (used by the Mk 13 Mod 4 and 5 GMLS). Both meters are made by the John Fluke Mfg. Co. Hewlett Packard Co. is another popular manufacturer of test equipment.

A "typical" digital multimeter is capable of measuring d.c. voltage and current, a.c. voltage and current, and resistance. Measured values, polarity signs, and an automatic decimal point location are displayed on seven-segment LED readouts. An overload (or overrange) indication also is displayed on the readout, usually as a flashing +88888.

Control switches on the meter's front panel are either pushbutton or toggle actuated. They activate the meter, select a function, and permit manual or automatic range selection. In autoranging mode, the meter will automatically switch upscale or downscale as necessary.

Power requirements for different digital multimeters vary. Some models, such as the 8600A-01 meter, use low-voltage d.c. batteries or a rechargeable power pack as a power source. Other models, such as the 8800A meter, must be plugged into a 115-volt a.c. power source/convenience outlet.

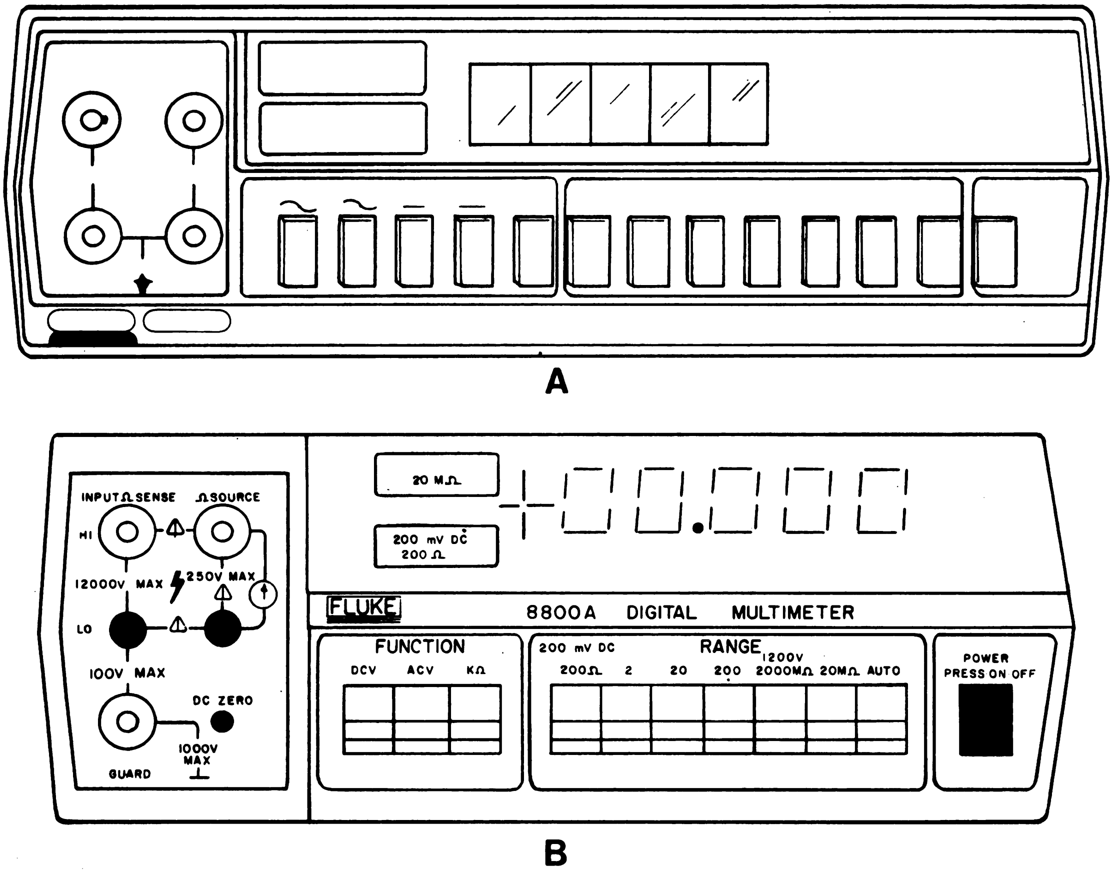

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Figure 11-21.—Digital multimeters: A. 8600A-01 (SCAT 4212); B. 8800A.

TECHNIQUES FOR METER USE

The multimeters we have described are the most common types of test equipment you will use for troubleshooting. Several techniques for using a meter are discussed in the following text. The techniques/methods suggested here are NOT all-inclusive. You will learn many other techniques for using a meter as your troubleshooting skills develop.

NOTE: We will assume your multimeter is set up properly for each test described. The test leads are plugged into the correct test jacks and the range and function switches are turned to the appropriate positions.

Current Tests

Of all the circuit tests you will make, a current test is the most infrequent. Generally, we are more interested in voltage and resistance types of checks. But sometimes current tests are required when you deal with power supply and amplifier circuits. If you need to make a current test, you must know how to use the meter correctly.

Before you measure a circuit, remember the golden rule of current testing. The rule is—AMMETERS/MULTIMETERS MUST ALWAYS BE CONNECTED IN SERIES WITH THE CIRCUIT OR COMPONENT BEING MEASURED. Connecting a meter in parallel with (or across) a component in a live circuit causes two problems. First, an incorrect or false current reading will be obtained. Second, the meter may be damaged because too much current will flow through it.

Therefore, BEFORE making a current test, you must open the circuit's wiring. That task could be as simple as lifting leads off a terminal board. In certain situations, you might have to unsolder a connection point also. After the circuit is opened, the meter's test leads are connected in series with the component(s) under test. (Refer to view A of figure 11-22.)

There is another technique (or trick) you can use to determine the current in a circuit. Measure the voltage across a resistor of known value in series with the component in question. From this you can calculate the current in the circuit. (Refer to view B of figure 11-22.) This particular technique has the advantage of eliminating the need to open a circuit.

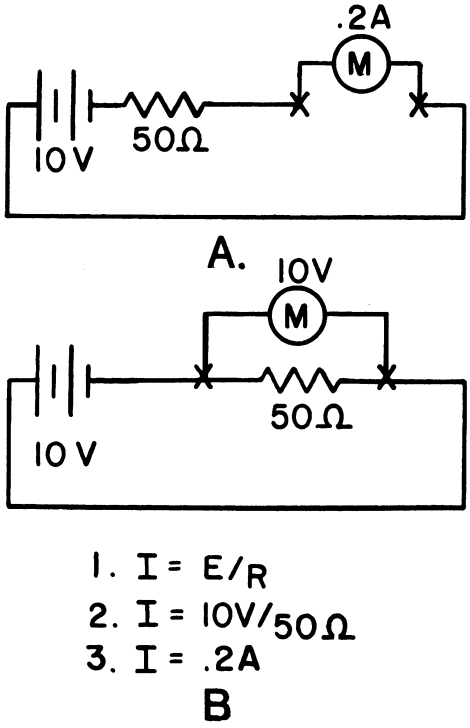

Figure 11-22.—Current tests.

Current tests must be made with the power applied to the circuit. Be aware of the ever-present danger of electrical shock. Follow all prescribed safety precautions to prevent injury to personnel and damage to the equipment.

Voltage Tests

The most common type of circuit test you will make with a multimeter is a voltage test. During preventive maintenance, voltage tests are used to verify the equipment is operating properly. For example, the polarity and values of selected missile orders are checked during a system test. Those voltage readings are taken at the simulator of the GMTR/TSAM. Periodically, the output of GMLS power supplies must be checked. If the output voltage levels are not within prescribed tolerances, the power supply must be adjusted to MRC specifications.

During troubleshooting procedures, voltage tests are made to isolate the cause of a casualty. For the most part, you will check for the presence or absence of proper voltage levels throughout a circuit/signal path. Improper voltage levels can cause some odd effects in a circuit's operation, especially in solid-state circuitry. Another important voltage test made during troubleshooting procedures checks the condition of switch and relay contacts.

Before measuring any circuit, you should always check the power source first. Ensure the power distribution panel is activated correctly and that circuit breakers and fuses are not tripped or blown. Then double-check your multimeter. Verify the function switch is set to a.c. or d.c. as required. Turn the range switch to its highest scale. Defective circuit elements may cause higher than normal voltages to be present at a test point. Therefore, start your voltage readings on a "safe" scale to protect the meter movement. Switch the meter to lower ranges to obtain a more accurate (around mid-scale) reading.

When measuring voltage, remember two important points. First, VOLTMETERS/ MULTIMETERS MUST ALWAYS BE CONNECTED IN PARALLEL WITH THE CIRCUIT OR COMPONENT BEING MEASURED. Second, voltage measurements must be made with the power applied to a circuit. Again, be careful of the electrical shock hazard and follow ALL prescribed safety precautions.

A BASIC VOLTAGE TEST.—The techniques used to make a basic voltage test are fairly simple. Let's assume you must measure the voltage drop across each resistor in the circuit shown in figure 11-23. Your first step should be to consult a reference diagram. Identify the test points to be used. Then set your meter's function and range switches accordingly. Keep in mind, you will connect the meter in parallel with each resistor when you take the measurements.

The basic test procedure requires that you touch the tips (or probes) of the test leads to the circuit. Note the test lead connections around resistor R1. Energize the circuit and read your meter, switching to lower ranges if appropriate.

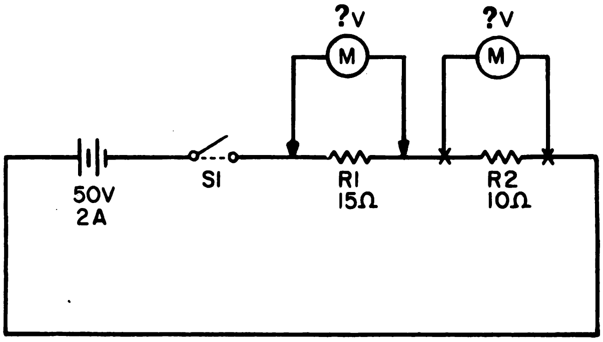

Figure 11-23.—A basic voltage test.

As we said, the basic test procedure is fairly simple, but it does present one minor problem. You must use both of your hands to hold the test leads on an energized circuit. Should you accidentally slip, you might end up on a live circuit and . . . ouch!

Many test leads are equipped with tips that can be removed or unscrewed. A special alligator clip test probe can be installed in place of the regular tip. Now you may attach/clip the test lead to the circuit (deenergized of course) and remove your hand or hands. We recommend you use that procedure when taking any kind of measurement from a live circuit. Not only is it safer, but your hands are free to work the meter or do other tasks. Note the test lead connections around resistor R2.

By the way, what are the measured voltage drops across resistors R1 and R2 in the circuit in figure 11-23? You can use Ohm's law and formula to calculate those values quite easily. The reading across R1 should be 30 volts d.c. The reading across R2 should be 20 volts d.c.

MEASURING CONTACTS.—Whenever a relay or solenoid coil fails to energize during a normal operational sequence, you have a casualty. Chances are very good that the signal path to the coil was interrupted. Troubleshooting steps usually trace the cause of the problem to an open set of contacts. A voltage test is used to determine the opened or closed condition of switch and relay contacts. Refer to figure 11-24 as we describe the techniques used to measure voltage across contacts with a meter. (Supply voltage for each circuit in the figure is 115 volts a.c.)

The first measurement you should make ensures supply voltage is available to the circuit. (Refer to views A and B of the figure.) Connect your meter between the supply and return (or common) power lines. The reading obtained should be 115 volts a.c. or full supply voltage in both circuits.

In view C, the meter has been connected across a closed set of contacts. What do you think the meter reading should be—0 or 115 volts a.c.? The correct answer is 0. That reading is obtained because current will ALWAYS take the path of LEAST resistance. The closed contacts offer no resistance to the flow of current. The internal circuitry of the meter offers a much higher resistance. Therefore, circuit current flows through the contacts and bypasses the meter. The voltage reading across a closed set of contacts will be 0 volts.

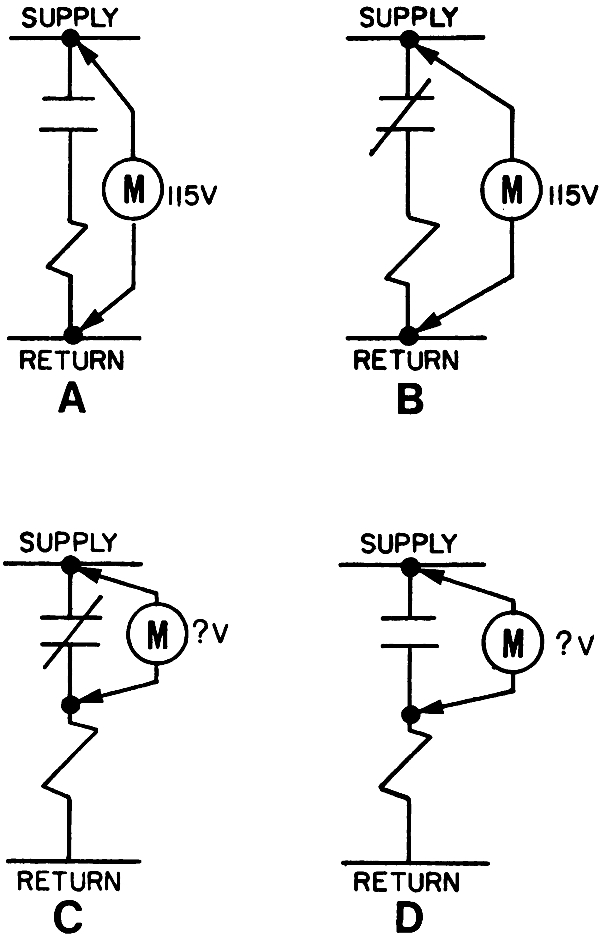

Figure 11-24.—Measuring voltage across contacts.

In view D, the meter has been connected across an open set of contacts. The meter reading will be 115 volts a.c. in this case. The open contacts offer maximum (or infinite) resistance to the flow of current. The internal circuitry of the meter offers less resistance and creates a path for current. As a result, a voltage drop (equal to source voltage) is indicated on the meter.

Refer to the simple interlock circuit shown in figure 11-25. We will use that example to describe how measuring contacts can isolate a fault. Be sure you follow the standard procedures we have mentioned previously. Check a reference diagram (electric schematic) and identify test points. Prepare your meter and ensure supply voltage is available to the circuit.

In view A, the meter is connected across the SILA1-1AB contacts. A reading of 0 volts indicates those contacts are closed; that is not our problem. Move to the next set of contacts in the signal path. In view B, the meter is connected across the SIMA2-2CD contacts. (An optional test lead connection point is shown.) A reading of 115 volts a.c. indicates those contacts are open

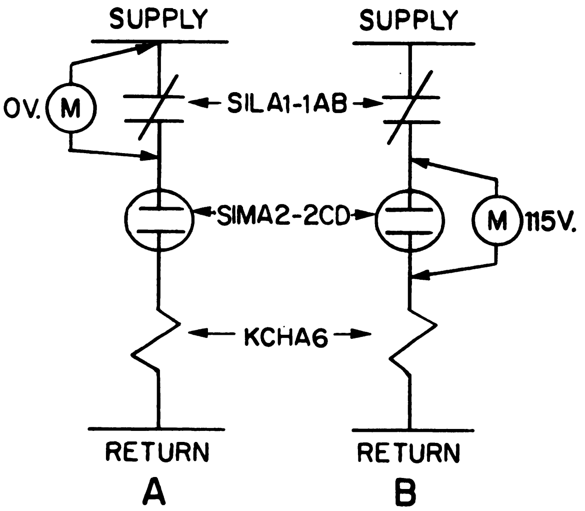

Figure 11-25.—Isolating faults with voltage tests.

and you have isolated the problem. Replace the switch and the casualty is corrected.

Now refer to figure 11-11. The same troubleshooting procedure described above can easily be applied to an actual circuit. To save time, we recommend you mentally divide a large signal path into sections—such as a top half and a bottom half. Measure across several contacts in the top half of the circuit first. If you obtain a 0-volt reading, all those contacts are closed. Then, measure the bottom half of the circuit. If you obtain a 115-volt a.c. reading, you have (at least) isolated the problem to the bottom half of the circuit.

Now divide the bottom half of the circuit into smaller sections consisting of one or two contacts only. Take more voltage readings until you isolate the one bad contact. That procedure should sound familiar to you. It is identical to steps 3, 4, and 5 described in figure 11-1 of a logical trouble isolation procedure.

There are several other techniques for using a meter to measure voltage. You will learn them on the job. However, be sure you remember how to interpret voltage readings across contacts. Closed contacts = 0 volts; open contacts = 115 volts a.c. (or supply voltage).

Resistance Tests

The third type of circuit check made with a multimeter is a resistance test. In this capacity, the multimeter is essentially a low-range voltmeter. The voltage measured is supplied by the meter's own low-voltage d.c. power source—a battery. Therefore, all resistance measurements are made AFTER the power is secured to a circuit. Capacitors, which store an electrical charge, must be discharged too. The meter movement can be damaged if it is connected to an energized circuit.

There are four basic types of resistance checks you will make during maintenance and troubleshooting procedures. They include (1) measuring a component, (2) continuity tests, (3) test for shorts, and (4) test for grounds.

The technique for measuring the resistance value of a component (such as a resistor) is fairly simple. The meter is always connected in parallel with the device being tested. However, be sure you study the reference diagram carefully. Look for parallel circuit connections. Remember what happens to resistance in a parallel circuit. False readings can be obtained very easily. You may have to isolate the component from its circuit to receive a valid resistance measurement.

CONTINUITY TESTS.—An electric circuit is functional only when its conductors form a complete and unbroken path for current. The test used to check for opens/breaks in a circuit is called a continuity test. A multimeter set to measure resistance is used to make the test. (In a pinch, two sound-powered telephone handsets could be used.)

Normally, the continuity test is held on circuits where resistance is low. An open is indicated by a high or infinite resistance reading on the meter. For continuity testing, the meter is always connected in SERIES with the circuit or conductor being checked.

Figure 11-26 demonstrates the basic techniques for testing the conductors of a cable. Note that both plugs are disconnected from their jacks. In this manner, all possibilities of parallel circuit interference are eliminated. Also, the power to the circuit is secured and the meter is connected in series with the conductor being tested.

First, let's check continuity on the A conductor (seen in view A). Note the test lead and jumper wire connections at both plugs. Current from the meter flows through plug 2 and the A conductor to plug 1. From plug 1, current continues through the jumper wire and passes to ground. The ship's metal structure now serves as the return path to the meter. In short, we have just described a complete, unbroken circuit path. The meter will read 0 ohms or a very low resistance reading. A similar test of conductors B and C will produce identical results.

Using the same test techniques, a continuity check of the D conductor isolates our casualty. The open point in plug 2 interrupts the meter's current path. As a result, a maximum resistance reading is obtained which indicates an open circuit. What was the purpose of using the ship's structure during the continuity test?

Obviously, it was used to establish a return path for the meter. That technique (or trick) is often necessary when checking continuity between two distance points.

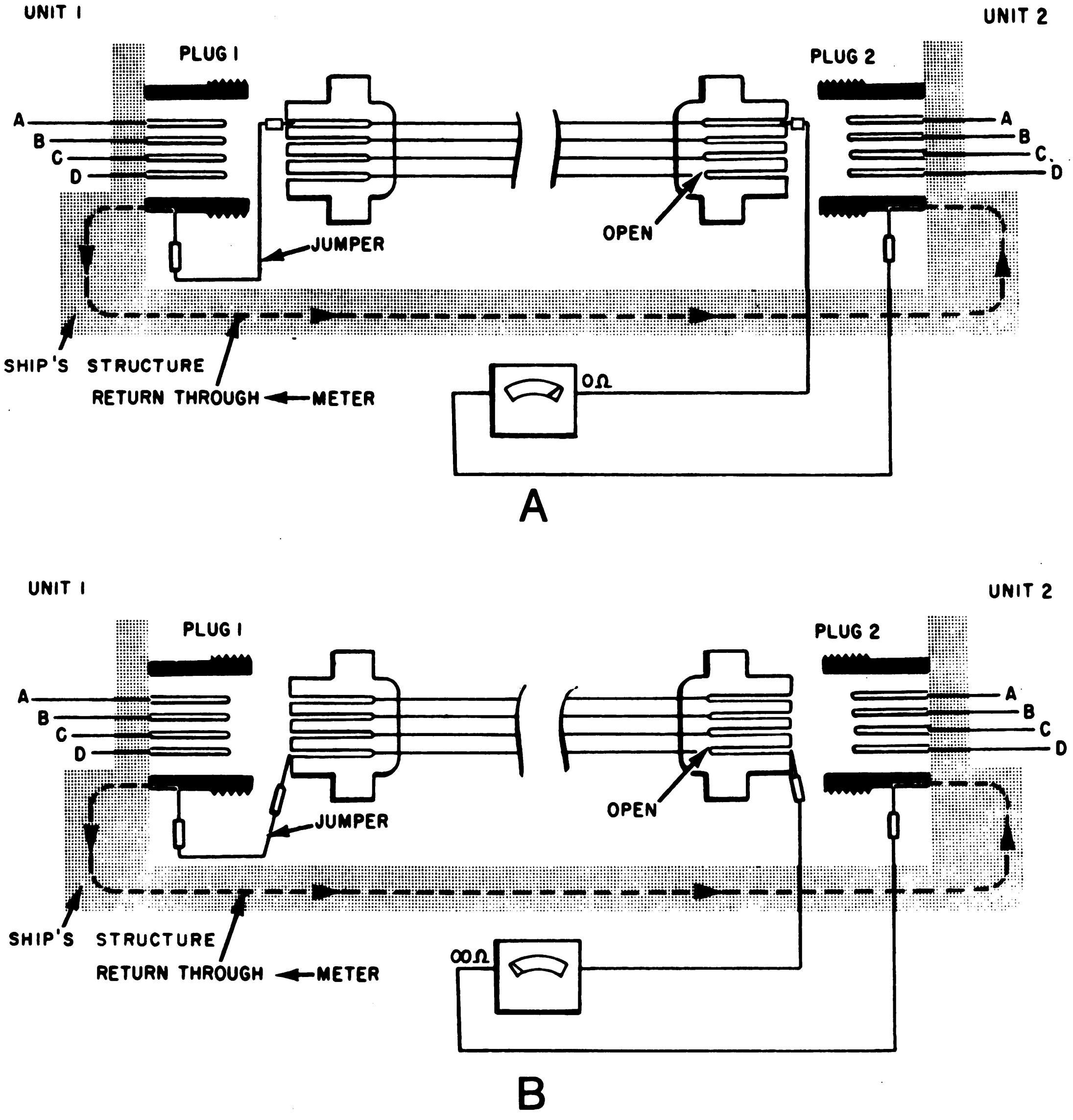

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Figure 11-26.—Continuity tests.

TEST FOR SHORT.—A short circuit occurs when one electric conductor accidentally touches another. The "connection" may be direct or through another conductive element. Two wires with frayed insulation may touch and cause a short. Too much solder on a pin of a connector (plug or jack) may short to an adjacent pin. Most of the time, a short circuit allows enough current flow to blow a fuse or trip a circuit breaker. However, there are exceptions to this rule.

A short circuit condition can be detected with a multimeter. You measure the resistance between the two suspected conductors. A short will indicate a low or zero resistance reading. For example, let's assume there is a short between the A and B conductors in figure 11-26. Disconnect both plugs (as shown) and remove the jumper wire. Connect your meter's test leads to the A and B points on plug 2. A short will produce a low/zero resistance reading; a good condition should produce a high or infinite resistance reading.

Shorts usually occur in components that have windings or coils. Transformers, solenoids, relays, synchros, and electric motors are such examples. Oil-soaked and deteriorated insulation on cables is another good cause for shorts. Generally, short-circuited components should be replaced or, in the case of a motor, rebuilt. Shorted connections inside plugs and jacks can be repaired (sometimes) if they are re-soldered carefully.

TEST FOR GROUNDS.—Grounded circuits are a major problem in any equipment that contains thousands of electrical connections. A GMLS definitely falls within that category and we can guarantee you will "chase" a ground or two in your career. A grounded circuit occurs when an electrical conductor makes contact with the ship's metal structure (or ground).

Some circuits are intentionally grounded. The ship's structure can serve as a common return path for a circuit. The outer covering (or braiding) of shielded or coaxial cabling is purposely connected to ground. In this manner, stray electrical interference is passed to ground and the cable's sensitive signal is not distorted. (Shields are often used on the missile order signal cabling.) Grounding is required as a safety measure on many installed and portable electrical equipments. Motors and hand-operated power tools must be grounded for your personal safety. Do not disturb intentionally grounded circuits.

Most of a GMLS's wiring is designed so it is above ground. When a ground occurs in this wiring, you have a problem. Frayed insulation around a wire often permits the conductor to make direct contact with ground. Some technicians refer to that condition as a "hard" or "solid" ground. Oil- or water-soaked cabling is another common cause for grounds. The liquid acts as a conductive element and permits an indirect connection between a conductor and ground. Some technicians refer to that condition as a "partial" ground.

A circuit ground may or may not blow a fuse or trip a circuit breaker. However, most grounds in a GMLS will activate the ground detection meter on the EP1 panel. We will discuss a ground detection meter shortly.

A multimeter can be used to locate a ground. By measuring the resistance to ground of any point in a circuit, you can determine if the point is grounded. The technique for testing a cable to ground can be seen in figure 11-26 again. Disconnect both plugs and remove the jumper wire. Connect one test lead to ground and the other to a conductor in the cable (as shown). A high or infinite meter reading indicates that the conductor is not grounded. A low or zero resistance reading indicates that the conductor is making contact ground. A low reading may indicate a "partial" ground. A zero resistance reading usually means a "hard" ground. In either case, the grounded condition must be cleared.

Meggers

Ideally, the insulating material around a conductor should present a maximum resistance to the flow of current. However, if the insulation begins to deteriorate or break down, its resistance (or insulating quality) lowers. The end result is that an unwanted current path is created. The current "leakage" could cause a short or ground situation in a circuit.

A megger is a portable meter used to test the insulation resistance of a conductor. The term "megger" is derived from megohmmeter—an instrument capable of measuring resistance in millions of ohms. Sometimes meggers are referred to as insulation breakdown test sets.

You may wonder why an ordinary ohmmeter/multimeter is not used to hold insulation breakdown tests? There are two reasons. First, the scales of regular meters are not that accurate in the high megohm ranges. Second, the battery potential of a regular meter is too weak (small) to break through the insulation. A megger is designed to produce the very large voltage potential which is necessary to detect an insulation breakdown.

Figure 11-27 illustrates a typical megger. It consists of a hand-driven d.c. generator and an indicating meter/scale. Most meggers are rated at a 500-volt d.c. output. They are usually equipped with a friction clutch too. If the

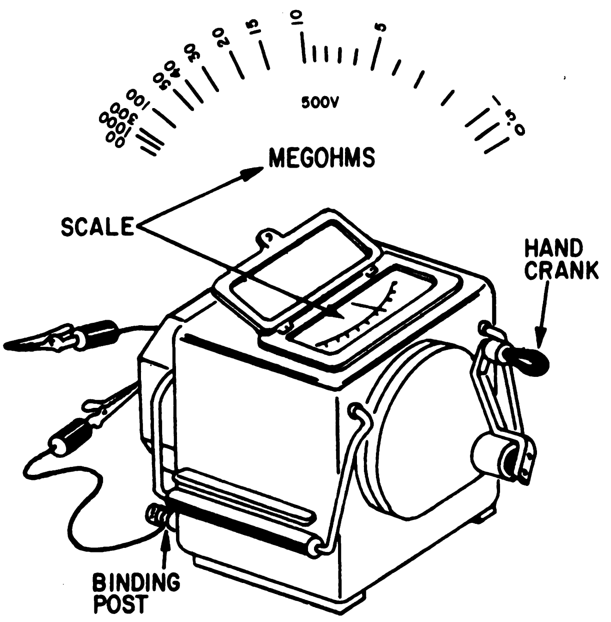

Figure 11-27.—A typical megger.

generator is cranked faster than its rated speed, the clutch slips. Thus, output voltage is not permitted to exceed its rated value. Two test leads are furnished with the megger. They are connected to the − and + binding posts.

PREPARING A MEGGER.—Before using a megger, you should do three quick checks to ensure it operates satisfactorily.

- First, check infinity with the test leads disconnected from the megger. Turn the hand crank at its rated speed. The meter's pointer should remain on infinity.

- Second, check infinity with the test leads connected to the megger, but not shorted together. Turn the hand crank. The meter's pointer should still remain on infinity. That indicates the test leads are in good shape.

- Third, check zero with the test leads shorted together. Do NOT hold the test leads together with your fingers or you may get "zapped." Turn the hand crank. The meter's pointer should be used to zero the megger at this time.

Now, the megger is ready for use. But before you connect the test leads to a circuit/component, remember two golden rules. The first rule is—NEVER USE A MEGGER ON AN ENERGIZED CIRCUIT. The second rule is—NEVER USE A MEGGER ON LOW-VOLTAGE CIRCUITS OR COMPONENTS. That rule is quite important and applies to solid-state circuitry in particular. Solid-state components are NOT designed to operate on 500 volts. They will be damaged if subjected to a megger's output potential.

USING A MEGGER.—There are several types of insulation breakdown tests that can be made with a megger. Two common tests you may have to make are (1) testing to ground and (2) testing for shorts between conductors (in a multiconductor cable).

When you are testing to ground, the megger's negative test lead is attached to the conductor under test. The positive test lead is connected to the equipment frame, the cable's outer insulation (or sheathing), or to a ship's ground. When testing the insulation resistance between two conductors in a common cable, simply connect the megger's test leads to each conductor. Then turn the megger's hand crank and watch the meter's pointer.

What measurement constitutes a good or bad megger reading? Let's use the insulation breakdown test between two conductors (in a common cable) as an example. A reading of infinity or a high-resistance reading means the insulation between the two conductors is very good. A reading of zero or a very low resistance reading means you have a short. The insulation between the conductors is "bad" and that cable should be replaced.

In some cases, certain equipments or conductors are assigned a minimum insulation resistance value. Megger readings above the minimum value are acceptable; readings below the minimum value indicate trouble. Normally, those standards or minimum specifications are listed on the equipment's PMS MRCs and should be consulted.

Ground Detection Meters

A ground detection meter and associated circuitry are located on the front of most GMLS EP1 power panels. Sometimes it is referred to as a ground fault meter or indicator. Figure 11-28 illustrates the schematic arrangement and major components of the device. You may consider the ground detection meter as a piece of built-in test equipment.

The ground detection meter (MEZ1) is an a.c. voltmeter-relay combination. It monitors both sides (supply and return) of the GMLS's control supply voltage for shorts to ground. During normal operating conditions, the meter's movable pointer stays centered between two adjustable, but stationary, setpoint indicators (needles). The pointer often "hovers" around the center point and is rarely steady. However, that is a normal reaction.

When a ground occurs in the system, the pointer begins to move toward one of the setpoint indicators. If the ground is on the supply (or WS) line, the pointer moves left toward the low setpoint. If the ground is on the return (or WSS) line, the pointer moves right toward the high setpoint. Should your system develop a "partial" ground, the resistance of the line to ground will still be high. The pointer moves off center, but not far enough to touch a setpoint indicator.

If the resistance of a line to ground is low enough, you have developed a "hard" ground. In this situation, the pointer moves over far enough to touch one of the setpoints. That condition closes a set of contacts in the meter. The meter contacts for both setpoint indicators are wired to a lamp and a buzzer. The lamp starts flashing and the buzzer starts buzzing (rather loudly too). Those indicators alert personnel to the presence of a ground somewhere in the system.

OTHER TEST EQUIPMENT

There are many other types of test equipment available to help you troubleshoot a casualty.

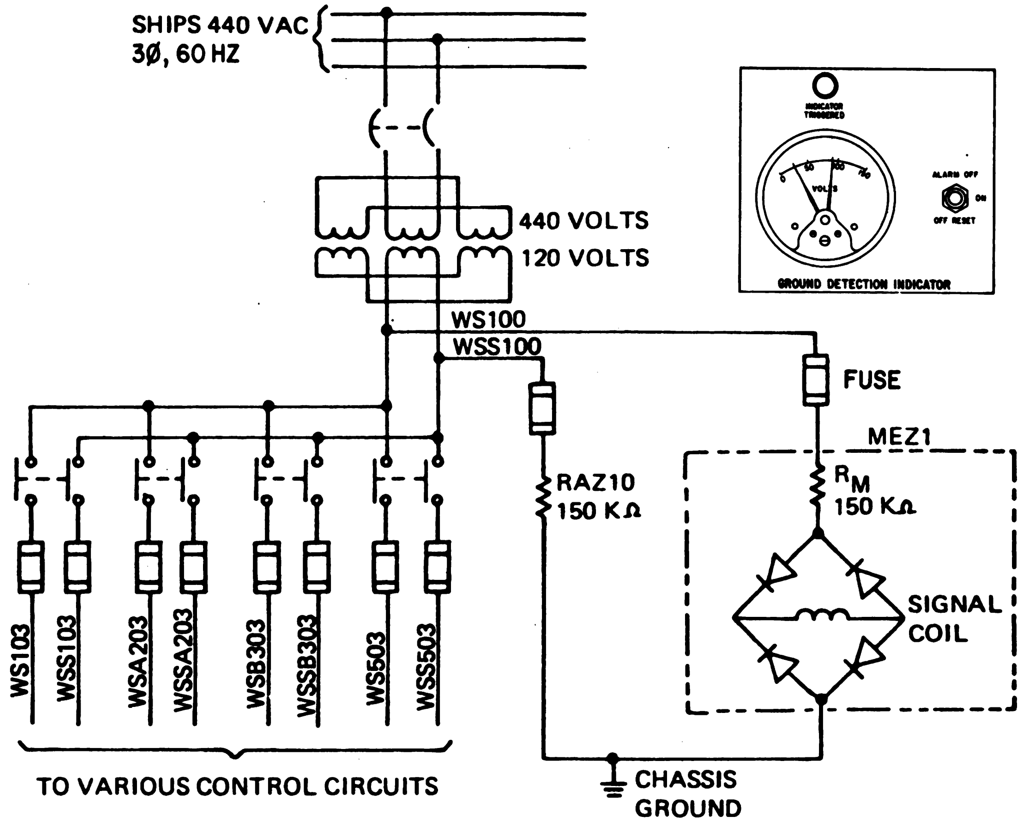

Figure 11-28.—Ground detection meter.

Your GMLS may be equipped with relay testers, solenoid testers, switch testers, logic probes, and so on. Those simple devices are used in conjunction with the basic multimeter during trouble isolation procedures.

Depending on the casualty, you may have to turn to the more "sophisticated" types of test equipment to solve a problem. Oscilloscopes, signal generators, frequency counters, vacuum tube voltmeters (VTVMs) and so forth are such examples. Generally, we are not issued that type of test equipment because a regular multimeter meets our needs in most cases. However, those equipments are available should you require them. We suggest you see your friendly FTs, ETs, ICs, or DSs.

This text will not describe the "special" types of test equipment. Suffice it to say they exist and they are available should you need them. There are reference materials/training manuals you can consult to learn about such equipment. *Introduction to Test Equipment,* NEETS Module 16, should be published in the near future. We recommend you obtain it for additional information.

There is one piece of unique test equipment we will briefly discuss. It is the timing code and logic status (TCLS) selection and display module used on the Mk 13 Mod 4 (through 7) GMLS.

TCLS Module

The TCLS module is mounted (built-in) to the lower right-hand corner of the Mk 13 Mod 4 GMLS's EP2 control console. (Refer to item #30 on figure 2-56.) In terms of physical size and general appearance, the module is similar to an average pocket calculator. It is a part of the GMLS's test equipment and has the following capabilities.

1. It is used as an aid in isolating equipment faults.
2. It checks the status of selected logic circuits throughout the GMLS.
3. It checks time delay intervals and equipment cycle times.
4. It can locate the point of malfunction during unsuccessful automatic load cycles.

The TCLS keyboard and display module (figure 11-29) allows numbers to be entered

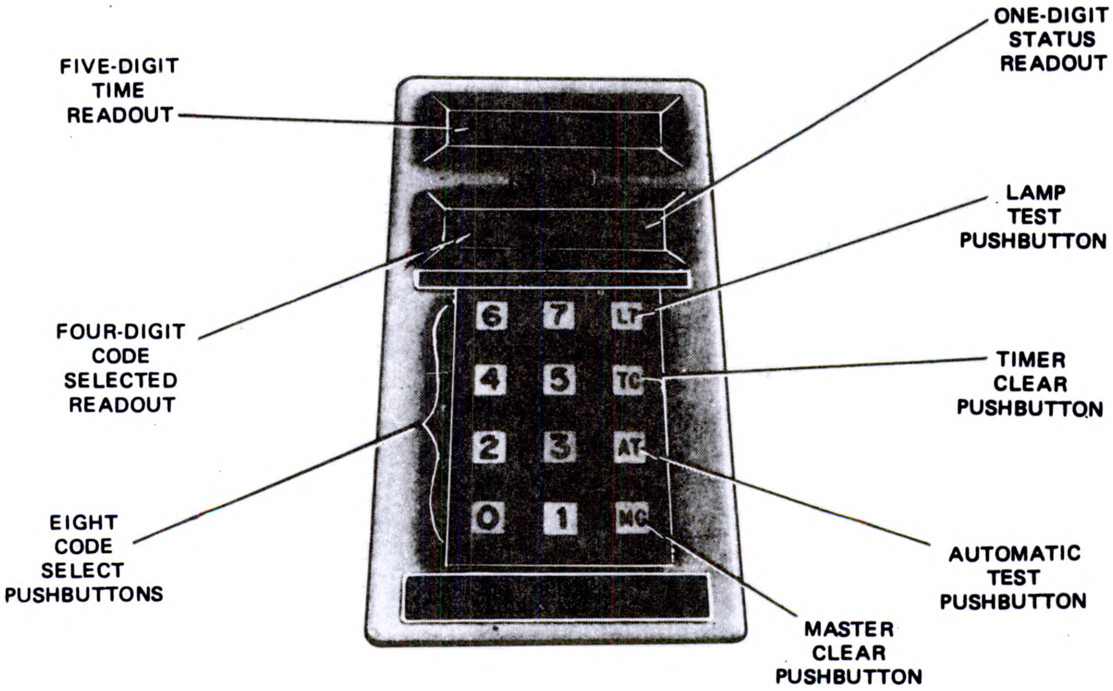

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Figure 11-29.—TCLS keyboard and display module.

and digits to be displayed. The numbers are entered with the eight code select pushbuttons (0 through 7). The numbers entered are displayed on the four-digit code selected readout. If the number entered is not a time check code, a status is displayed on the one-digit status readout. Any time check code number entered causes five zeros to be displayed on the five-digit time readout. The zeros are displayed until the function to be timed is initiated.

Besides the eight code select pushbuttons, the keyboard contains four other pushbuttons. They are lamp test (LT), timer clear (TC), automatic test (AT), and master clear (MC) pushbuttons. The LT pushbutton allows you to test all readout display segments. When the LT pushbutton is depressed, all readout segments should display a .8 at each digit location. The TC pushbutton allows you to reset the five-digit time readout to zero. By pressing the pushbutton, additional time checks on the same timing function are made without reentering the code select number. The AT pushbutton allows you to isolate malfunctions during an auto-load cycle. When the AT pushbutton is depressed, the step control pushbutton lamp associated with the malfunction starts

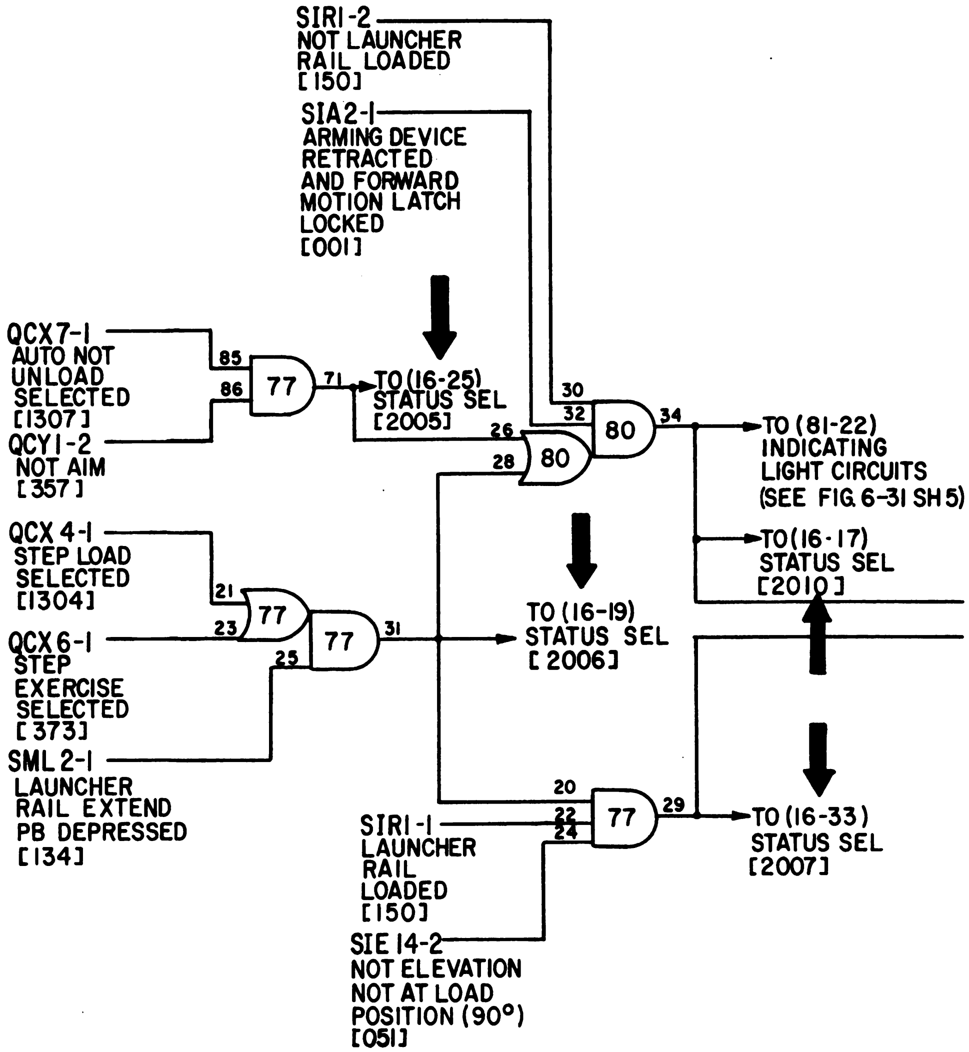

Figure 11-30.—A typical logic circuit; status select test point codes identified.

flashing. The MC pushbutton allows you to clear the previously selected code. Pressing the pushbutton can also advance the search beyond an irregular status when the TCLS is in sequence generator control.

Logic circuit test points are assigned code numbers. Different code numbers are assigned to logic cycle time check points. Blocks of numbers are used as codes. The number blocks are:

- Numbers 0 through 377—each circuit with a code from this block has two test points monitored.

4

- Numbers 400 through 777—not used.
- Numbers 1000 through 1777—each circuit with a code from this block has only one test point monitored.
- Numbers 2000 through 2377—each circuit with a code from this block has only one test point monitored.
- Numbers 3000 through 3077—each circuit with a code from this block has two cycle time check points monitored.

Each logic circuit with a code from 0 through 377 has one test point labeled –1 and one test point labeled –2. The one-digit status readout indicates the status of a 0 through 377 coded circuit by displaying one of four possible digits (0 through 3). The status readout digits indicate:

1—displayed when the –1 test point is high and the –2 test point is low.

2—displayed when the –2 test point is high and the –1 test point is low.

0—irregular status; displayed when both test points –1 and –2 are low.

3—irregular status; displayed when both test points –1 and –2 are high.

Each logic circuit with a code from 1000 through 1777 or from 2000 through 2377 has only one test point. Therefore, only one of two status conditions can exist:

1—displayed when the test point is high.

2—displayed when the test point is low.

A typical logic circuit is shown in figure 11-30. (This particular circuit is actually a portion of the full circuit shown in figure 4-66.) However, in figure 11-30 we have highlighted the status-select test point codes—2005, 2006, 2007, and 2010. The status of any logic test point can be checked by entering the test point code (e.g., 2005, 2006, and so on) on the keyboard.

The test point code is then applied to shift registers (figure 11-31). The output from the shift registers drive the code readout display and control the multiplexers. Each logic test point is tied to a multiplexer. The code stored in the shift registers determines which logic test point on which multiplexer is checked for status. The output of the selected multiplexer is applied to the status readout display.

When any code from 0 to 377 is entered on the keyboard, the shift registers select two multiplexers and two logic test points. The two logic test points are compared and a status is displayed. Also, logic test points with codes from 0 through 377 are automatically status-checked in sequence when the keyboard is not in use. A generator applies a new code to the shift registers every 20 milliseconds, as long as no irregular status is found. Because the codes change so quickly, only the third digit of the code readout is displayed and the status readout is not displayed. The third digit displayed changes continuously (0-1-2-3-0-1-2-3) to inform you the generator is in operation. If an irregular status (0 or 3) is discovered, the generator stops. The logic test point code is fully displayed, and the status is displayed.

When checking the cycle time of a circuit, you must enter a time check code (three-thousand series) on the keyboard. The code is applied to shift registers. The outputs from the shift registers drive the code readout display and control the multiplexers. Each cycle time test point is tied to a multiplexer. Two multiplexers start and stop a timer. The output of the timer is displayed on the elapsed time readout.

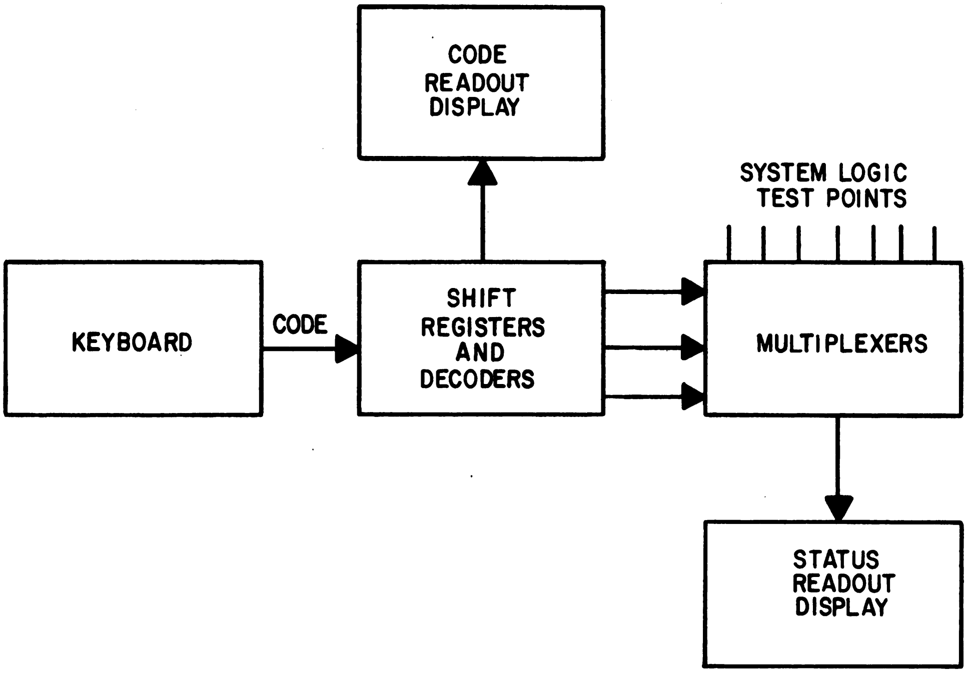

Figure 11-31.—Logic test point status check; keyboard control.

TCLS Module—Summary

We fully realize that you may not have "absorbed" all the information presented in the last section. For instance, the text has not described shift registers or multiplexers which are special purpose ICs.

The intent of the information was only to familiarize you with another piece of test equipment. You can certainly consider the TCLS module as a built-in multimeter—and much more. Devices such as the TCLS module have proved to be extremely valuable troubleshooting and general maintenance aids. Many of our GMLSs are scheduled to receive solid-state updates in the near future. Chances are very good that devices similar to the TCLS will be installed in those systems. Why, one day multimeters might be a thing of the past!

Hydraulic Test Kits

A hydraulic test kit is another piece of test equipment. A typical kit is shown in figure 11-32. It contains various pressure gauges, regulating valves, a test hose, and assorted adapters, nipples, and couplings. The hydraulic test kit is a pressure testing/measuring device. It is used to check fluid operating pressures at selected test points throughout the GMLS.

An example of the kit's use would be to check the servofluid and supercharge fluid pressures of a power drive system. Typical servofluid and supercharge fluid pumps (dual-gear pumps) produce a 400-psi servofluid pressure and a 100-psi supercharge fluid pressure. These pressures can be tested by removing the test plugs on the system's auxiliary relief valve block (figure 11-33). Use the proper adapters and test gauges to connect the test kit to those points.

Pressure tolerances vary among GMLS hydraulic systems. Usually a 10- to 20-psi difference is acceptable for most operating pressure. You should consult your MRCs for exact instructions.

By the way, do you remember Pascal's law? Basically, it states that pressure in a fluid power system is equal and undiminished throughout the system. Do you recall the formulas used to calculate force (F), area (A), and pressure (P)?

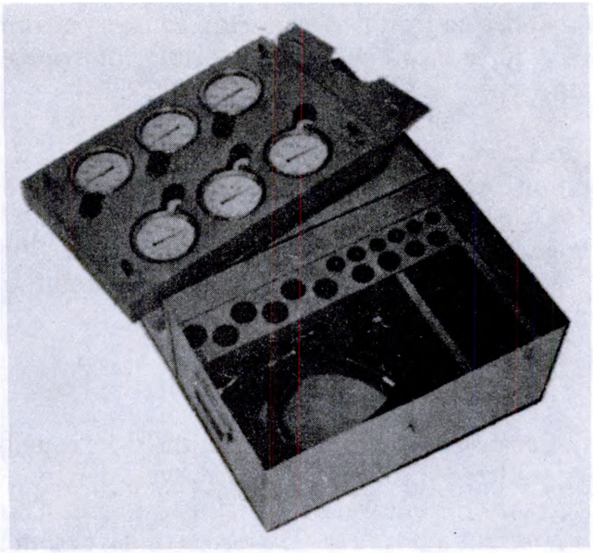

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Figure 11-32.—Hydraulic test kit.

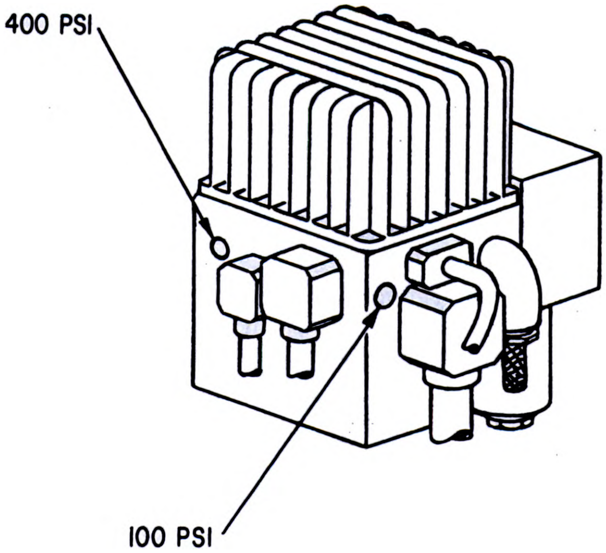

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Figure 11-33.—Hydraulic test points.

The diagram in figure 11-34 illustrates the relationships between the three factors. Do not forget these basic rules and formulas. They are helpful when you must troubleshoot a hydraulic or pneumatic casualty.

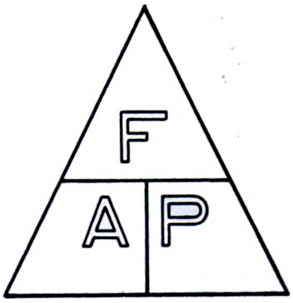


Figure 11-34.—Formula diagram to determine force, area, and pressure.

TRANSISTORIZED AND PRINTED CIRCUITS

The use of transistors and other solid-state devices in GMLS equipment is constantly increasing. Because of its versatility, the transistor is used in many circuit applications. Its miniature dimensions make the transistor particularly suitable for use in unitized and modular constructed equipment. For the same reason (miniaturization and compactness), troubleshooting equipment which contains transistors is more difficult.

TROUBLESHOOTING TRANSISTOR CIRCUITS

The first step in troubleshooting transistor circuits is a visual inspection of the entire equipment. Loose connections, broken leads, and any other visible damage should be repaired first. A careful visual inspection will frequently shorten what could otherwise be a lengthy troubleshooting job.

If the equipment is still inoperative after the visible defects have been corrected, troubleshooting must continue. The next step is to locate the defective stage by means of signal-substitution or signal-tracing. Make voltage and resistance tests to isolate the defective component(s).

Multimeters used for voltage measurements in transistor circuits should have a high ohms-per-volt sensitivity. That feature ensures an accurate reading is obtained. A 20,000 ohms-per-volt meter or an electronic voltmeter (VTVM) with an input resistance of 11 megohms or higher on all voltage ranges is preferred.

Meters which pass a current of more than 1 milliampere (mA) through the circuit under test cannot be used safely in testing transistor circuits. Before using a meter to measure resistance on a transistor circuit, check the current the meter passes on all ranges. To check the current passed by the meter, set it up for resistance measurements. Connect a milliammeter in series with the test leads. Observe the milliammeter reading on all ranges. Do not use any range for testing that passes more than 1 mA.

Conventional test probes, when used in the closely confined areas of transistor circuits, often are the cause of accidental shorts between adjacent terminals. In many electric circuits, the momentary short caused by the test probes rarely results in damage. But, in transistor circuits, this short can ruin a transistor. Also, transistors are very sensitive to improper bias voltages. The sensitivity of a transistor to surge currents should always be borne in mind when testing transistor circuits.

Another change transistors require from the conventional troubleshooting procedure is the use of a small, low-wattage soldering iron. The iron's tip must have a narrow point or wedge. Wattage ratings on the order of 35 to 40 watts are satisfactory. The common type of soldering gun or iron used on electric circuits should not be used on transistor circuits.

Testing Transistors

A meter can be used to test transistors by measuring the collector-base, and emitter-collector back-to-front resistance ratio. A front-to-back resistance ratio of 500:1 should be obtained for the collector-base and emitter-base checks. The front-to-back ratio of the emitter-collector check should be nearly equal. All three checks should be made. Experience has shown that transistors can develop shorts between the emitter and the collector and still have good ratios between the emitter-base and collector-base. Resistance checks on crystal diodes should produce a 10:1 or greater front-to-back ratio.

Because of the shunting resistances in transistor circuits, you will normally have to disconnect at least two transistor leads to perform these resistance checks. If possible, of course, remove the device from the circuit.

When performing resistance checks on transistors, use a meter scale which limits the testing current to values NOT exceeding 1 mA. Many meters in use are designed so that the R × 1 range allows up to 100 mA or more to flow through the part under test. This amount of current can damage a transistor.

Servicing Precautions

Because of their reliability, transistors usually are soldered into a circuit. However, it may be necessary to remove a transistor to test it. That can present a problem—exposure to heat from a soldering iron. The transistor and other components mounted to the printed-circuit board may be damaged.

Transistors can be removed, however, if the proper precautions are observed. Take care to prevent damage to the transistor from the heat of the soldering iron. Also, handle the leads carefully, as they are very brittle. Do not remove or replace a transistor until the power source is secured.

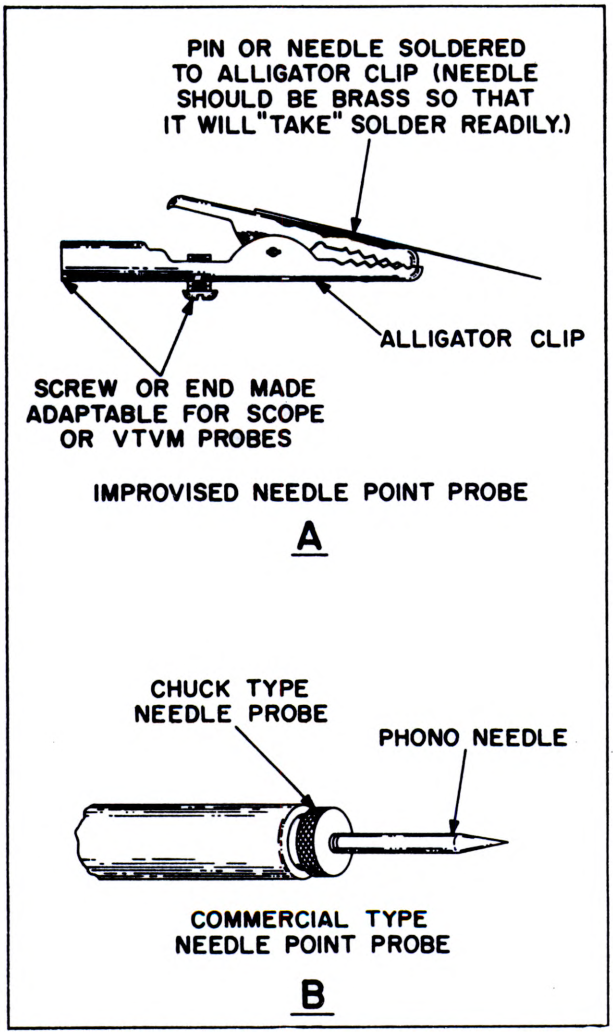
Before removing a transistor for replacement, note the orientation of the collector, base, and emitter leads. Preshape and cut the leads of the new transistor to the proper length. Use sharp cutters to prevent undue stress on the leads entering the transistor. Pigtail leads should have a minimum clearance of one-sixteenth inch between bend and transistor body. Shape any bend required in a gradual curve. Sharp (90°) bends are not acceptable. With the transistor properly positioned, solder the leads to the connections. Use the proper solder, soldering iron, and a heat sink. Do not hold the soldering iron to the work any longer than necessary. Large quantities/globs are not needed.

For stability of the electrical characteristics, the hermetic seal of the transistor must be maintained. This seal protects the transistor from the effects of moisture, dust, and so on. Remember that temperature is the critical factor affecting transistor life. Keep it as low as possible. It has been estimated that for every 10 °C (about

18 °F) the junction temperature is lowered, the life of the transistor is doubled. Conversely, for every 10 °C the junction temperature is raised, the life of the transistor is halved. Keeping the circuits cool by every practical means is part of the trade in solid-state electronics.

PRINTED CIRCUITS

The troubleshooting procedures for printed circuits are similar to those for conventional circuits. However, the repair of printed circuits requires considerably more skill and patience. The printed circuits are small, compact, and require special servicing techniques.


PIN OR NEEDLE SOLDERED TO ALLIGATOR CLIP (NEEDLE SHOULD BE BRASS SO THAT IT WILL "TAKE" SOLDER READILY.)
ALLIGATOR CLIP
SCREW OR END MADE ADAPTABLE FOR SCOPE OR VTVM PROBES
IMPROVISED NEEDLE POINT PROBE
A
CHUCK TYPE NEEDLE PROBE
PHONO NEEDLE
COMMERCIAL TYPE NEEDLE POINT PROBE
B

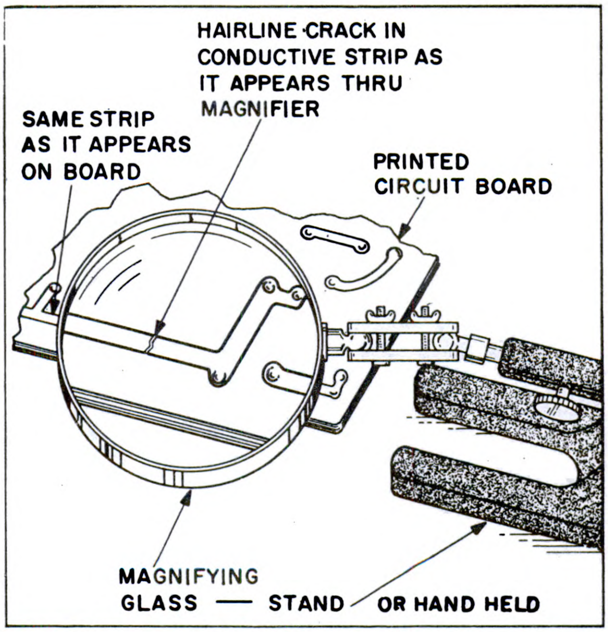
70.109

Figure 11-35.—Needle probes.

First check the defective printed circuit to determine whether any prior servicing has been done. The defective part should be pinpointed before attempting to trace trouble on a printed-circuit board. See if the conducting strips are coated with a protective lacquer, epoxy resin, or similar substance. If so, carefully scrape it away. Better still, use a pin or chuck-type needle probe to penetrate the coating so that continuity checks can be made (figure 11-35).

Breaks in the conducting strip (foil) can cause permanent or intermittent troubles. In many instances, these breaks will be so small that they cannot be seen with the naked eye. These almost invisible cracks can be located with the aid of a hand- or stand-held magnifying glass (figure 11-36).

The most common cause of an intermittent condition is poorly soldered connections. Other causes are broken boards, broken conducting strips, fused conducting strips, arc-over, and loose terminals.


HAIRLINE CRACK IN CONDUCTIVE STRIP AS IT APPEARS THRU MAGNIFIER
SAME STRIP AS IT APPEARS ON BOARD
PRINTED CIRCUIT BOARD
MAGNIFYING GLASS — STAND OR HAND HELD

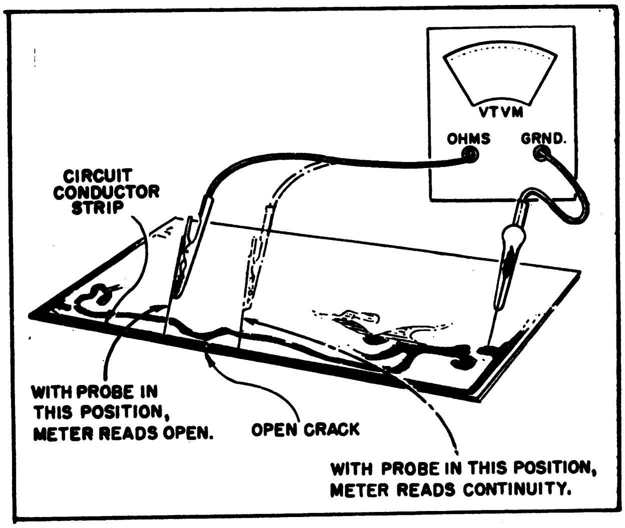
70.110

Figure 11-36.—Using a magnifying glass to locate hairline cracks.

You may have to check the conducting strips of a printed-circuit board. To do so, set up a multimeter for making point-to-point resistance tests using needle-point probes (figure 11-37). Be sure the meter does not pass a current in excess of 1 mA. Insert one point into the conducting strip close to the end of terminal. Place the other probe on the terminal or opposite end of the conducting strip. The multimeter should indicate continuity. If the multimeter indicates an open circuit, drag the probe along the strip until the multimeter indicates continuity. If the strip is coated, puncture the coating at intervals. Mark the open area and then use a magnifying glass to locate the fault (as shown in figure 11-36).

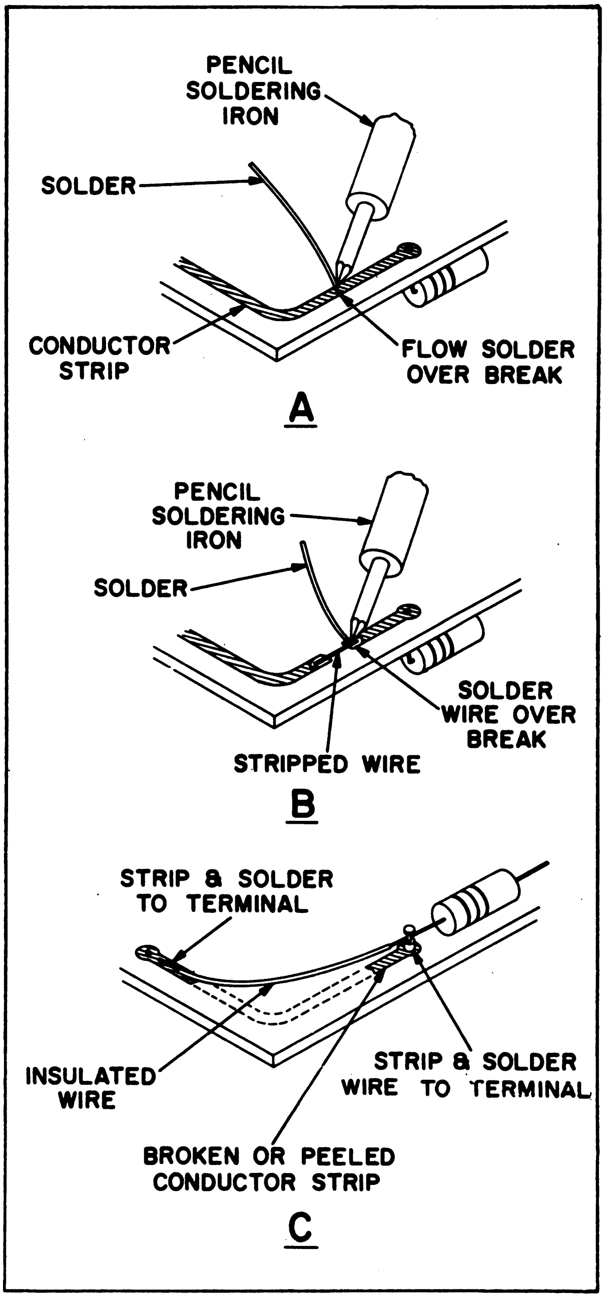
Figure 11-38 illustrates three methods of repairing broken conductive strips on printed-circuit boards. If the break in the conducting strip is small, lightly scrape away any coating covering the area to be repaired. Clean the area with a firm bristle brush and an approved solvent. Repair the cracked or broken area of the strip by flowing solder over the break (as shown in view A).

If there is any indication that the strip might peel, use the repair procedure shown in view B. Use a small section of bare wire 2 inches long to bridge the break. Apply solder along the entire length of the wire to bond it solidly to the


VTVM
OHMS
GRND.
CIRCUIT CONDUCTOR STRIP
WITH PROBE IN THIS POSITION, METER READS OPEN.
OPEN CRACK
WITH PROBE IN THIS POSITION, METER READS CONTINUITY.

70.111

Figure 11-37.—Using a meter to locate a break in a conductive strip.



70.112

Figure 11-38.—Three methods of repairing broken conductive strips.

conducting strip. Take care in applying the solder. It must not flow onto or near an adjacent strip. Keep the solder within the limits of the strip being repaired.

If a conducting strip is burned out or fused, a repair can be made as shown in view C. Cut and remove the damaged strip from the board. Connect a length of insulated wire across the break or from solder point to solder point as shown. It is best not to glue or bond a conducting strip that has been lifted or peeled from the board. Instead, clip off the raised section of the strip. Replace it with insulated hookup wire from solder point to solder point. Always check printed-circuit boards carefully after repairs for solder droppings that may cause shorts.

Frequently, a low-resistance leakage path will be created by moisture or dirt that has carbonized onto the board. This leakage can be detected by measuring the suspected circuit with a multimeter. To correct this condition, clean the carbonized area with a solvent and stiff brush. If that does not remove the carbon deposit, use a scraping tool (spade end of a solder-aid tool or its equivalent) to remove the substance.

Most printed-circuit boards have areas of conduction known as grounding conductors. These areas usually are located at each edge of the board, or on the parts-mounted side of the board. The grounding conductors are conducting strips used for grounding parts. They also serve as a mounting contact for the chassis or common ground. Occasionally an intermittent condition will result if the grounding screws or mounting screws become loose. If that occurs, tighten the screws. Then solder a good bond directly from the grounding strip to the chassis or equipment ground. If that is not practical, bond the screws (after tightening) with an epoxy resin or similar compound.

The most common cause for broken printed-circuit boards is careless handling. Be extremely careful while handling a board. Do not flex the board indiscriminately. Be especially careful when removing the board or replacing parts. Do not force anything associated with the board. It is advisable to use a chassis-holding jig or vise when servicing printed-circuit boards.

As a general rule, printed-circuit boards are NOT repaired by shipboard personnel. You only are required to isolate a problem to a particular board. But, in most cases, you are not permitted to replace a defective component on the bad board. Simply replace the entire board with a new one obtained from supply or from your authorized spares cabinet to correct the casualty. Return the board to supply personnel. They will ship it to an authorized facility for repairs.

There are certain situations when you might HAVE to make repairs to a printed-circuit board to fix a casualty. However, these situations are under emergency conditions only and such repair work must be approved by proper authority. If you must make emergency repairs to a printed-circuit board, we recommend you contact your FT, ET, IC, or DS buddies again. These personnel usually attend a microminiature repair course sometime during their careers. In short, they receive very specialized training and are qualified to do such sensitive work.

SYNCHRO SYSTEMS

You recall that there are two basic types of synchros—torque and control. The main difference between them is in their output. A torque system produces a mechanical output, while the control system's output is electrical. The transmitters for these systems are functionally and physically similar. However, in a torque synchro system, the transmitter is designated a torque transmitter (TX). The transmitter in the control system is designated a control transmitter (CX). The receivers in the two synchro systems are not only functionally and physically different, they are designated differently. The receiver in the torque system is designated a torque receiver (TR). The receiver in the control system is designated a control transformer (CT).

All GMLSs use a few torque synchros (TXs) to transmit launcher position information to the FCS. However, we are more concerned about the control synchros (CXs and CTs) in our launcher power drive servosystems. Therefore, the main emphasis in this section of the text is directed toward a control synchro system.

SYNCHRO SYSTEM ALIGNMENT

If synchros are to work together properly in a system, they must be correctly connected.

Additionally, they must be aligned in respect to each other and to the other devices, such as directors and launchers, with which they are used. The best of ordnance equipment would be ineffective if the synchros in the data transmission circuits were misaligned electrically or mechanically.

ELECTRICAL ZERO is the reference point for alignment of all synchro units. The mechanical reference point (MECHANICAL ZERO) for the units connected to the synchros depends upon the particular application of the synchro system. A missile launcher's mechanical reference points will be the centerline of the ship for train and a standard reference plane for elevation. Remember, whatever the system, the electrical and mechanical reference points MUST be aligned with each other.

There are several approved methods for aligning synchros. The best method is to align all synchros in a system to electrical zero. The units may be zeroed individually and only one person is required to do the work. Another advantage of using electrical zero is that any troubles in the system always show up in the same way.

Zeroing a synchro also means adjusting it mechanically. That ensures the synchro works properly in a system in which all other synchros are zeroed. Normally, the mechanical adjustment is made by physically turning the synchro's rotor or stator. NEETS Module 15, *Principles of Synchros, Servos, and Gyros* describes standard synchro mounting hardware. It also explains several methods for zeroing the various synchros. We recommend you consult that reference. Additional information about synchros and zeroing procedures can be found in the two references listed below.

1. *United States Navy Synchros, Description and Operation,* NAVORD OP 1303

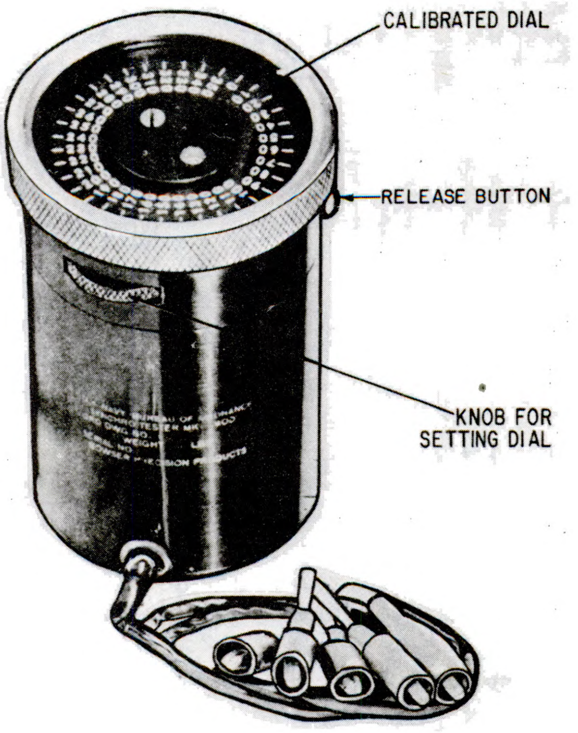
2. *Synchros, Description and Operation,* Military Standardization Handbook MIL-HDBK-225 (AS)

Don't forget the MRCs for your GMLS. They provide step-by-step instructions necessary to align and zero all the synchros in your equipment. Consult those MRCs.

Zeroing TXs, TRs, and CXs with a Synchro Tester

Synchro testers of the type shown in figure 11-39 are used primarily for locating a defective synchro. They also provide a fairly accurate method of setting transmitters and torque receivers on electrical zero. Control transmitters, torque transmitters, and torque receivers are functionally and physically similar. Therefore, they are zeroed in the same manner.

To zero a synchro with the tester, connect the units as shown in figure 11-40. Turn the synchro until the tester's dial reads zero degrees. That is the approximate electrical zero position. Momentarily short S1 to S3, as shown. If either the synchro or tester dial moves, the synchro is not accurately zeroed. You should shift the synchro slightly until there is no movement when S1 and S3 are shorted.



175.19

Figure 11-39.—A typical 400-hertz synchro tester.

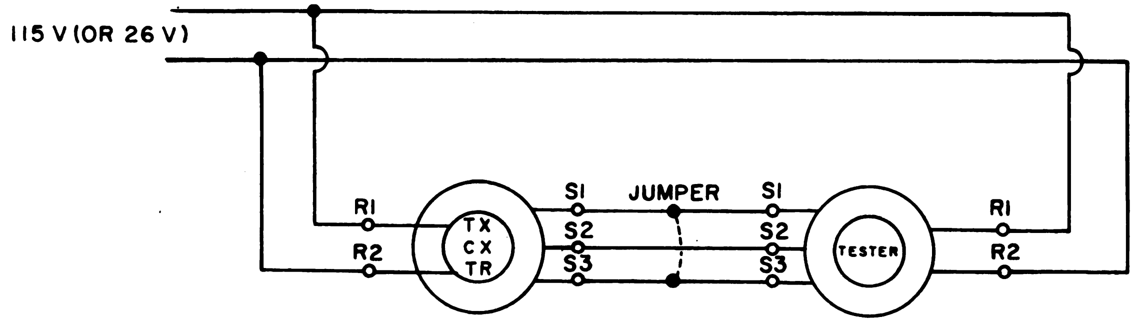


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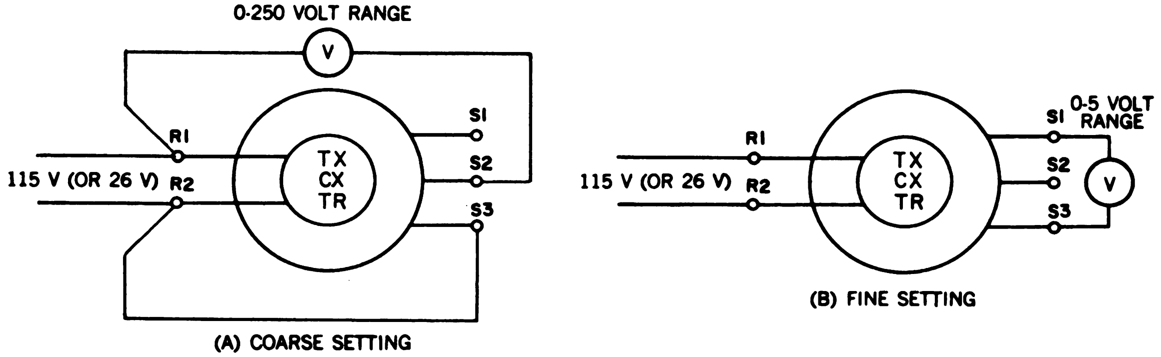
Figure 11-40.—Using the synchro tester to zero a synchro.



53.26

Figure 11-41.—Zeroing TXs, TRs, and CXs with a multimeter.

Zeroing TXs, TRs, and CSs with a Multimeter

Using a meter to measure voltage, the synchro zeroing procedure is broken down into steps as follows:

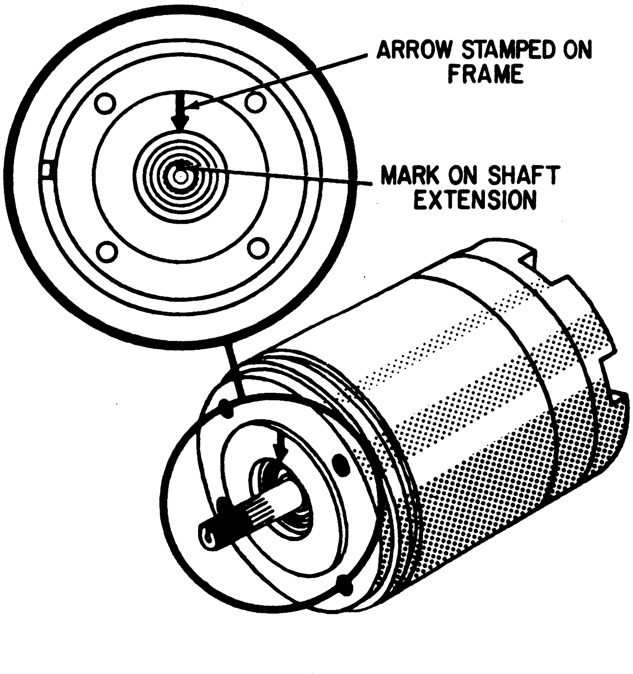
1. Carefully set the equipment/launcher to its zero or mechanical reference position.
2. Deenergize the synchro circuit and disconnect the stator leads. Set the meter to its 0- to 250-volt scale. Connect it into the synchro circuit as shown in view A of figure 11-41. Many synchro systems are energized by individual switches. Therefore, be sure that the synchro power is off before working on the connections.
3. Energize the circuit and turn the stator or rotor until the meter reads about 37 volts (15 volts for 26-volt synchros). This is the coarse zero setting and places the synchro approximately on electrical zero.
4. Deenergize the synchro circuit and connect the meter as shown in view B using the 0- to 5-volt scale.
5. Reenergize the circuit and adjust the synchro's rotor or stator for a null (minimum voltage) reading. This is the electrical zero or FINE position. Nulling a synchro is a very sensitive, trial-and-error procedure. Take your time and use a light touch. Also, if your meter has a 2.5-volt a.c. range, use that scale for greater accuracy. You will never obtain an exact zero volt reading because of the synchro's electrical characteristics. Strive for the lowest reading possible. One volt is okay, but .5 volt a.c. or less is much better.

A simple check on the common electrical zero position of a TX-TR synchro system can be done with a jumper. Put the transmitter and receiver on mechanical zero and, intermittently, jumper S1 and S3 at the receiver. The receiver should not move. If it does, the transmitter is not on zero and should be rechecked.

Zeroing a CT With a Multimeter

Two conditions must exist for a control transformer (CT) to be on electrical zero. First, its rotor voltage must be minimum when electrical zero voltages are applied to its stator. Second, turning the shaft of the CT slightly counterclockwise should produce a voltage across its rotor. This voltage should be in phase with the rotor voltage of the CX supplying excitation to the CTs stator.

The procedure used for zeroing depends upon the facilities and tools available and how the synchros are connected in the system. CTs may be zeroed by use of a meter, synchro testers, or with other synchros in the system. Regardless of the method used, there are two major steps in each zeroing procedure. First, the synchro must be set to its coarse setting. Then, after you are "in the ballpark," the synchro is adjusted/zeroed to its fine position.



175.18

Figure 11-42.—Coarse electrical zero markings on a synchro.

Many CTs (and other types of synchros) are marked in such a way that the coarse setting may be approximated physically. (Refer to figure 11-42.) An arrow is stamped on the synchro's frame and a line is etched onto the rotor's shaft. When those two marks are aligned with each other, the synchro is at its coarse, in-the-ballpark setting.

To zero a CT with a meter, use the following procedures:

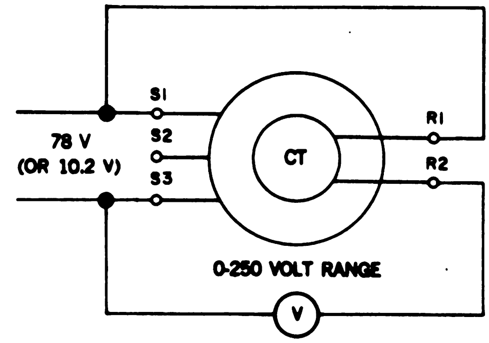
1. Set the mechanism which drives the CT rotor to zero or to its reference position. Also, set the transmitter (CX) that is connected to the CT to zero or its reference position.

2. Ensure the CX is zeroed and not sending a signal voltage to the CT. First, measure between S1 and S3 on the CX. You should obtain a 0-volt reading. Then measure between S2 and S3 (or S2 and S1) on the CX. At these points you should obtain a 78-volt a.c. reading. If those voltage readings cannot be obtained, it will be necessary to rezero the CX BEFORE attempting to zero the CT.

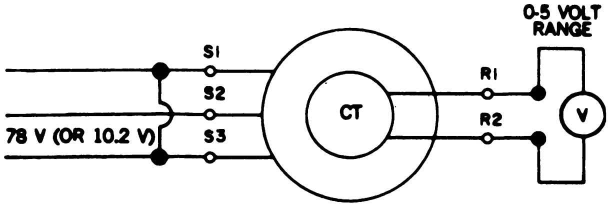
3. Deenergize the transmitter circuit. At the CT, disconnect leads and rearrange the circuit as shown in view A of figure 11-43. To obtain the 78 volts a.c. required by this configuration, leave the S1 lead attached to the CT. However, put the S2 lead on S3. Energize the transmitter circuit. Turn the CT's stator body to obtain a minimum reading on the meter's 250-volt scale. This is the coarse zero setting of the CT. If 78 volts a.c. from the transmitter circuit cannot be used, it is possible to use a 115-volt a.c. source. But the CT should not be energized for periods greater than 2 minutes. An overheating condition will develop and may cause permanent damage to the CT.

4. Deenergize the transmitter circuit. Reconnect the CT's S1, S2, and S3 lead. Rearrange the circuit as shown in view B of figure 11-43.

5. Reenergize the circuit. Start with a high scale on the meter and work down to the lowest scale. At the same time, carefully turn the stator of the CT until a zero/null reading is obtained. Clamp/secure the CT stator down with its



A COARSE SETTING



B FINE SETTING

55.36

Figure 11-43.—Zeroing a CT with a meter.

fastening hardware. Watch the meter to ensure the null reading does not change. This is the fine electrical zero position of the CT.

Alignment Summary

The described zeroing methods apply to all standard synchros and prestandard Navy synchros.

Before testing a new installation and before hunting trouble in an existing system, be certain all units are zeroed. Also, be sure the device's mechanical position corresponding to electrical zero position is known before trying to zero the synchros. The mechanical reference position corresponding to electrical zero varies. Therefore, we suggest that you read the instruction books and other pertinent information carefully before attempting to zero a particular synchro system. The MRCs and the OP for the system should be studied. There are likely to be some differences from the general instructions given in OP 1303 or NEETS Module 15. If an operational check indicates that a CT is not operating properly, replace it and zero the new CT.

MAINTAINING A SYNCHRO SYSTEM

Synchro units require careful handling at all times. Never force a synchro unit into place or drill holes in its frame. Do not use pliers on the threaded shaft or force-mount a gear or dial to the shaft. Two basic rules apply to all synchro units:

1. If it works, leave it alone.
2. If goes bad, replace it.

Synchros are no longer considered repairable items. Defective synchros should be disposed of in accordance with current instructions. Unless it is an emergency you must never take a unit apart or try to lubricate it. However, the gearing which drives the synchro should be well lubricated following MRC instructions.

TROUBLESHOOTING SYNCHRO SYSTEMS

Shipboard synchro system troubleshooting is limited to determining whether the trouble is in the synchro or in the system connections. All synchro casualties are not electrically related. When you are troubleshooting faulty synchro operation, consider friction a possible cause of the problem. Bearings must be especially clean to allow the synchro rotor to turn freely. The slightest sticking will cause an error in rotor position and result in a faulty output signal. Friction also may be caused by bent shafts and improper mounting of the synchro in the equipment.

While synchro adjustments are a vital part of maintenance, they are too numerous to be covered here. Instead we will pass on a word of caution. At the time of installation, your equipment was adjusted by well-qualified personnel using special tools and equipment. For this reason, future adjustments should be made only after qualified personnel have verified that an adjustment is necessary. A good habit to develop when making adjustments is to scribe gears at their original point of mesh. Count the number of threads or teeth to the position of the new adjustment. These measures will prove most helpful when an adjustment is later found to be incorrect or unnecessary.

In a newly installed synchro system, troubles are probably the result of improper zeroing techniques or wrong connections. Make certain all units are zeroed correctly, then check the wiring. Do not trust the cable markers of the wires. Make a continuity test to be sure you have the correct wire connected to the correct circuit point.

In systems which have been working, the most common trouble sources are:

- Switches—shorts, opens, grounds, corrosion, wrong connections.
- Nearby equipment—water or oil leaking into the synchro from other devices. If this is the trouble, correct it before installing a new synchro.
- Terminal boards—loose lugs, frayed wires, corrosion, and wrong connections.
- Zeroing—units improperly zeroed, mechanically and electrically.

Wrong connections and improper zeroing in any system are usually the result of careless work or inadequate information. Do not rely on memory when removing or installing synchros. Refer to the applicable MRC instructions.

POWER DRIVE PERFORMANCE TESTING

In chapter 6 we discussed the fundamentals of servosystems (the launcher's train and elevation power drives). The output of a "perfect" servosystem responded instantly to an applied input signal. The output was a mirror image of the input. A 10° input signal made the output (or load) move through an angle of exactly 10°. If the input signal rotated at a constant speed, the output followed faithfully at the same speed. The output remained synchronized with the input under all conditions. In short, the "perfect" servosystem performed "perfectly."

Power drive servosystems are NOT perfect and there always is some error between input and output quantities/performance. But if we can keep the errors within certain prescribed limits, the power drive can be said to be performing properly.

Who determines what these prescribed limits are? NAVSEA engineers set down specifications and define the limits for the private contractors who build a power drive. For example, the specifications may say that the launcher must follow a constant velocity signal of 10° per second. Also, the launcher must stay synchronized within 5 minutes of arc. That means the output shaft position must not go beyond 5 minutes of the input shaft position. To make sure the manufacturer has built the power drive to specifications, NAVSEA engineers will run a series of tests. One of these tests determines if the launcher follows a 10°/sec constant velocity signal and does not lag or lead it by more than 5 minutes. If the power drive does not meet this particular requirement, NAVSEA will not accept the power drive until it does.

The contractor adjusts the unit until it follows the constant velocity signal with an error of 5 minutes or less. A permanent record in the form of a tape is made to prove this fact. This record (called an acceptance test) is kept aboard ship as evidence that the power drive can and has met the performance standard. It gives you something to shoot for and is a record for later comparison. You can run the same test and compare your results with those of the acceptance test. When your maintenance test results are as good as (or better than) the acceptance test results, the power drive is performing at its best.

Many experienced technicians can use the "eyeball" technique for checking power drive performance. You can tell if a power drive is operating below acceptable standards by watching the action of the load. For example, the launcher overtravels three or four times when synchronizing to a fixed order signal. The most casual observer will notice that something is wrong. If the launcher hunts as the FCS director tracks a target, you know immediately something is wrong too.

But you can't tell from looking at the malfunctioning launcher where the source of the trouble is located. It might be in the FCS equipment (director or computer), or it might be in your gear. The only way to isolate the problem is to disconnect the launcher's power drives from all external signal sources. Then you run performance tests and compare the results to past standards.

There are three types of power drive test signals used to check the system's performance. They are (1) simple harmonic motion (SHM) orders, (2) constant velocity (CV) orders, and (3) fixed displacement (FD) orders. The special test equipments used to run those tests are (1) a dummy director and (2) an error recorder (figure 11-44).

DUMMY DIRECTOR

In remote control, the FCS computer is the normal source of input signals for the GMLS's servosystems. In local control, the GMLS's servosystems respond to signals from its fixed or dynamic synchros (CXs). A dummy director is a machine which provides an alternate source for those controlling signals. The dummy director is connected into the GMLS's EP3 test panel without disturbing normal wiring connections. You operate switches on the test panel to use/activate the dummy director during testing. When activated, all other signal sources are isolated from the power drive under test.

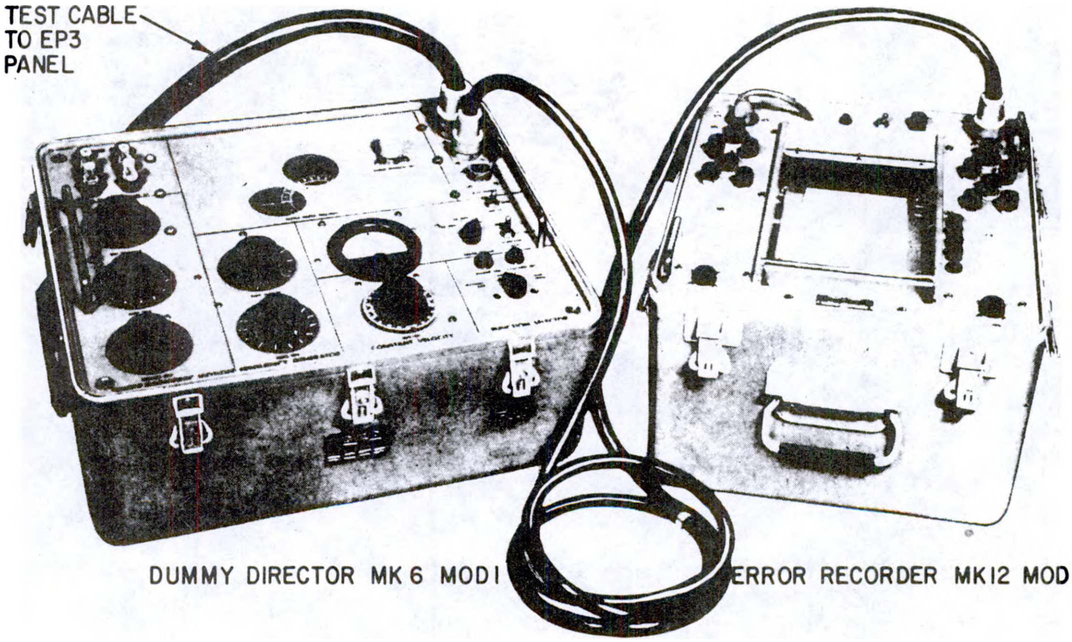


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Figure 11-44.—Typical dummy director and error recorder.

The basic components of the dummy director can be seen in figure 11-45. The main servo is a small motorized drive. It provides the mechanical input to the controlling synchros and a d.c. tachometer generator. The 1X and 36X CXs provide the primary position order signals to the 1X and 36X CTs inside the receiver-regulator. The 36X CT serves as an error detector. It receives a mechanical input from the main servo drive. It also receives an electrical input from a 36X test CX inside the receiver-regulator. The 36X CT compares the two inputs and develops an error signal. That signal is then supplied to the error recorder.

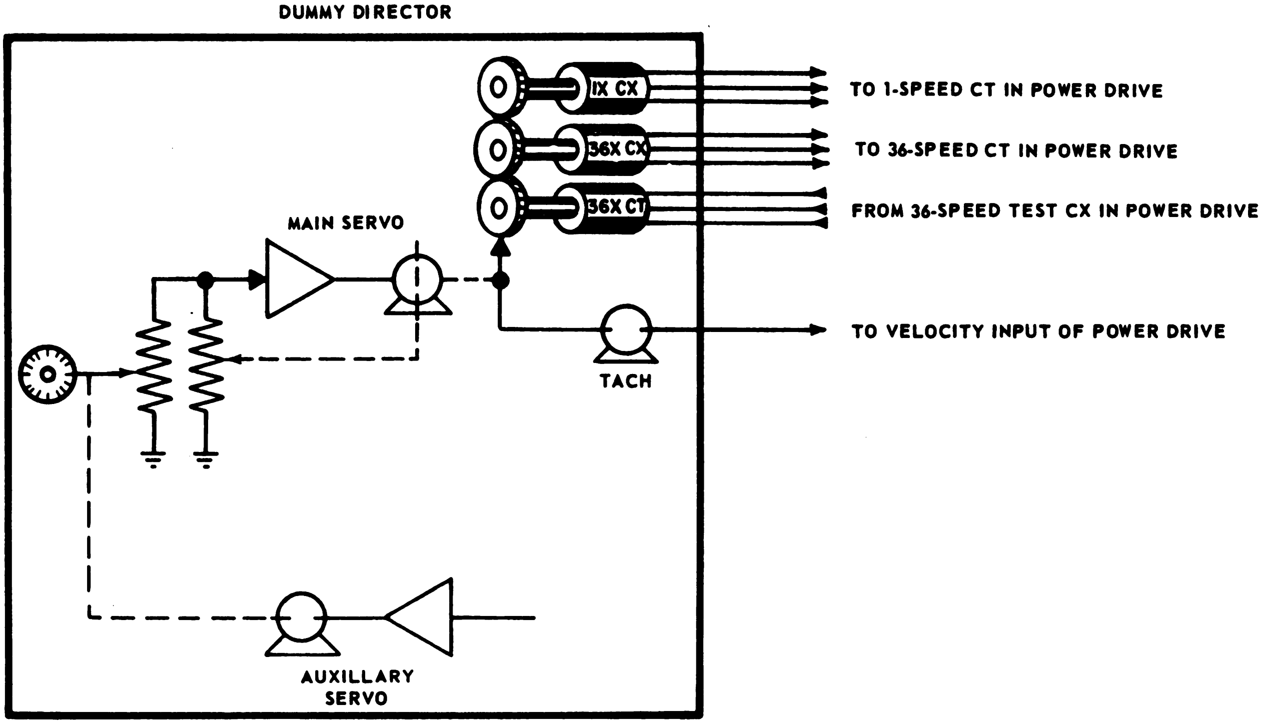
The d.c. tachometer generator develops the director velocity signal necessary with dynamic position orders. The velocity signal is supplied to the power drive's servoamplifier. The auxiliary servo is another small motorized drive mechanism. It is used to generate simple harmonic motion signals at selected frequencies or periods.

ERROR RECORDER

The error recorder is connected to the dummy director and provides a visual record of the test results. In principle, the error recorder is similar to an oscilloscope (o-scope). The o-scope displays its measured "sweeps" on a screen. The error recorder "traces" its measured values on special graph paper.

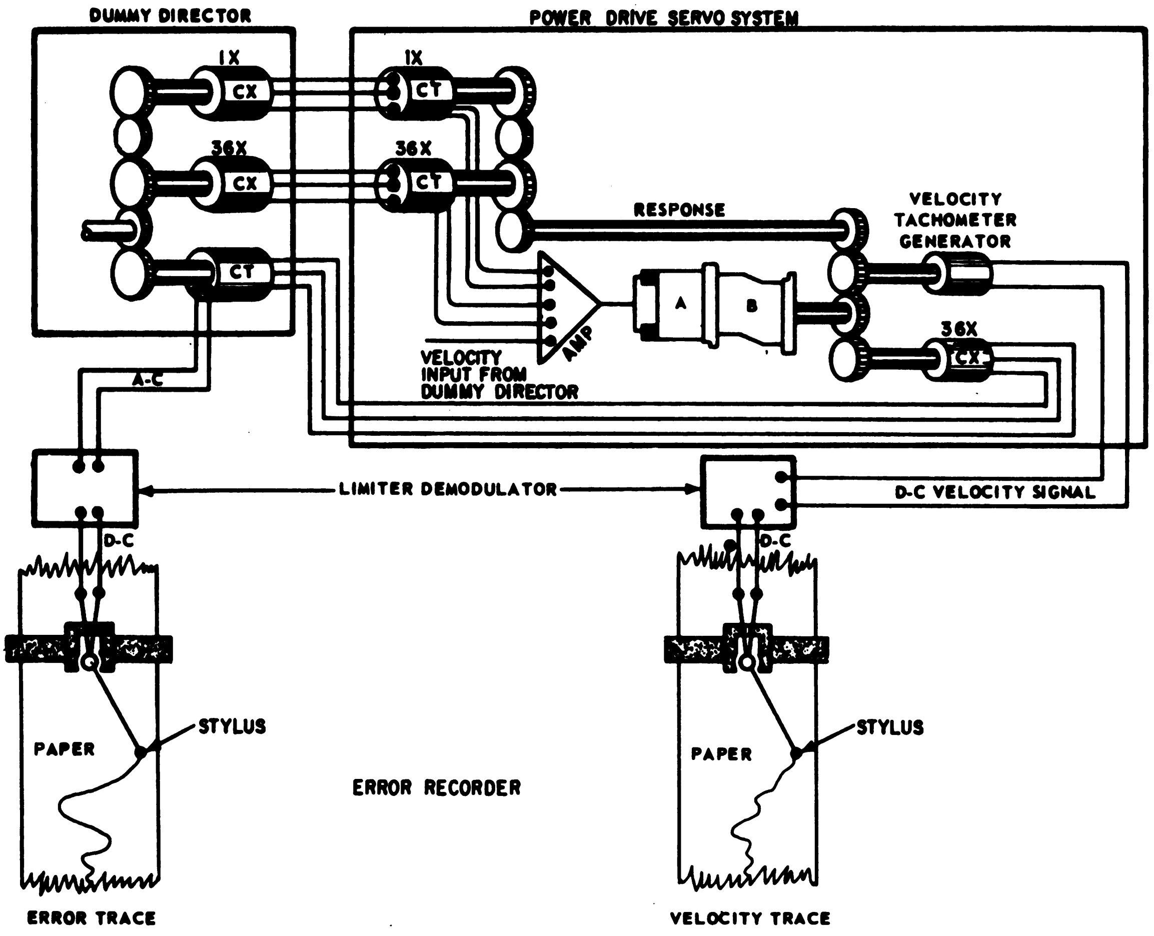
The error recorder contains two limiter-demodulators, two galvanometers, and two motor-driven rolls of paper. This dual arrangement permits the machine to record two different electrical values at the same time. Therefore, it is often referred to as a two-channel or dual-channel error recorder (figure 11-46).

The rolls of paper are fed past a fixed point at a speed controlled or selected by the operator. The galvanometer (D'Arsonval) movements provide the amplitude deflection of the pointers.


DUMMY DIRECTOR
IX CX
36X CX
36X CT
TO 1-SPEED CT IN POWER DRIVE
TO 36-SPEED CT IN POWER DRIVE
FROM 36-SPEED TEST CX IN POWER DRIVE
MAIN SERVO
TO VELOCITY INPUT OF POWER DRIVE
TACH
AUXILLARY
SERVO

83.141

Figure 11-45.—Basic components of a dummy director.



83.135

Figure 11-46.—Relationships between dummy director, error recorder, and power drive servosystem.

The galvanometers are mounted so pointer deflections are at right angles to the direction of paper travel. The tip of each pointer contains a stylus (similar to phonograph needle). Older models of error recorders use an ink stylus (pen) to write the trace on the paper. Newer models use an electric stylus which "burns" the trace onto special heat sensitive paper.

A separate limiter-demodulator unit is connected to each galvanometer. Basically, these units calibrate, balance, filter, and attenuate a test signal before it is fed to the recorder. The "limiter" section reduces (or attenuates) the size or magnitude of the input signal. That is necessary to prevent the pointer from driving the stylus off the paper during full deflection/signal strength. The "demodulator" section converts the a.c. error signal into a d.c. value. That is necessary because the galvanometers operate on d.c. current only.

Normally, both channels are used during performance tests. The first channel records the position error trace, the second channel records the velocity error trace. Figure 11-46 illustrates (functionally) where those test signals originate.

The details of how to set up and run power drive performance tests are outlined on your

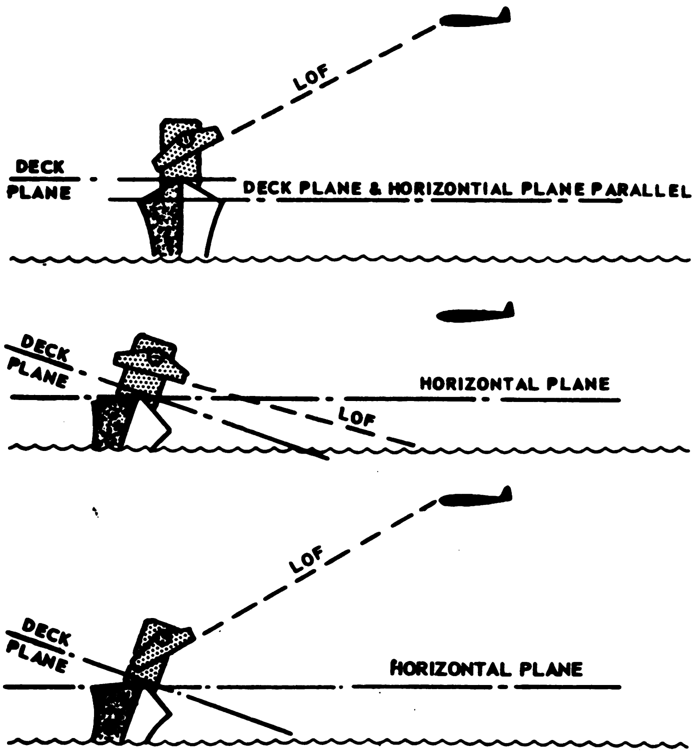
GMLS's MRCs. The MRCs also tell you how to interpret the test results recorded on the graph paper. The next three areas of the text will familiarize you with the types of tests performed.

Simple Harmonic Motion Signals

What is a simple harmonic motion? Figure 11-47 answers that question. As the ship rolls from side-to-side, the launcher's line of fire (LOF) to the target changes. The up-and-down motions of pitch have the same effects. To compensate for these motions, the FCS computer generates correcting signals. These signals are added to the launcher's position and velocity orders. The end result is that the launcher's line of fire is stabilized despite the motions of the ship underneath it. A dummy director can be considered a "motion" simulator. It can reproduce electrical order signals that represent the motions experienced during roll and pitch. Additionally, these dummy director signals can be controlled. You can select three values:

1. The magnitude or size of the SHM signal, which determines how far the launcher rotates in train or how far the guide arm(s) travel in elevation or depression movements
2. The period of the SHM signal, which determines how long the launcher/guide arm(s) take to complete a cycle
3. The reference point of the SHM signal, which determines the starting point of the test's train bearing or elevation angle.

Figure 11-48 illustrates the motions of a launcher training in response to an SHM signal. The dummy director is developing a signal that is applied to the train power drive. We have selected 45° bearing as the REFERENCE point to start our test. Any bearing could have been chosen. We also have "programmed" the dummy



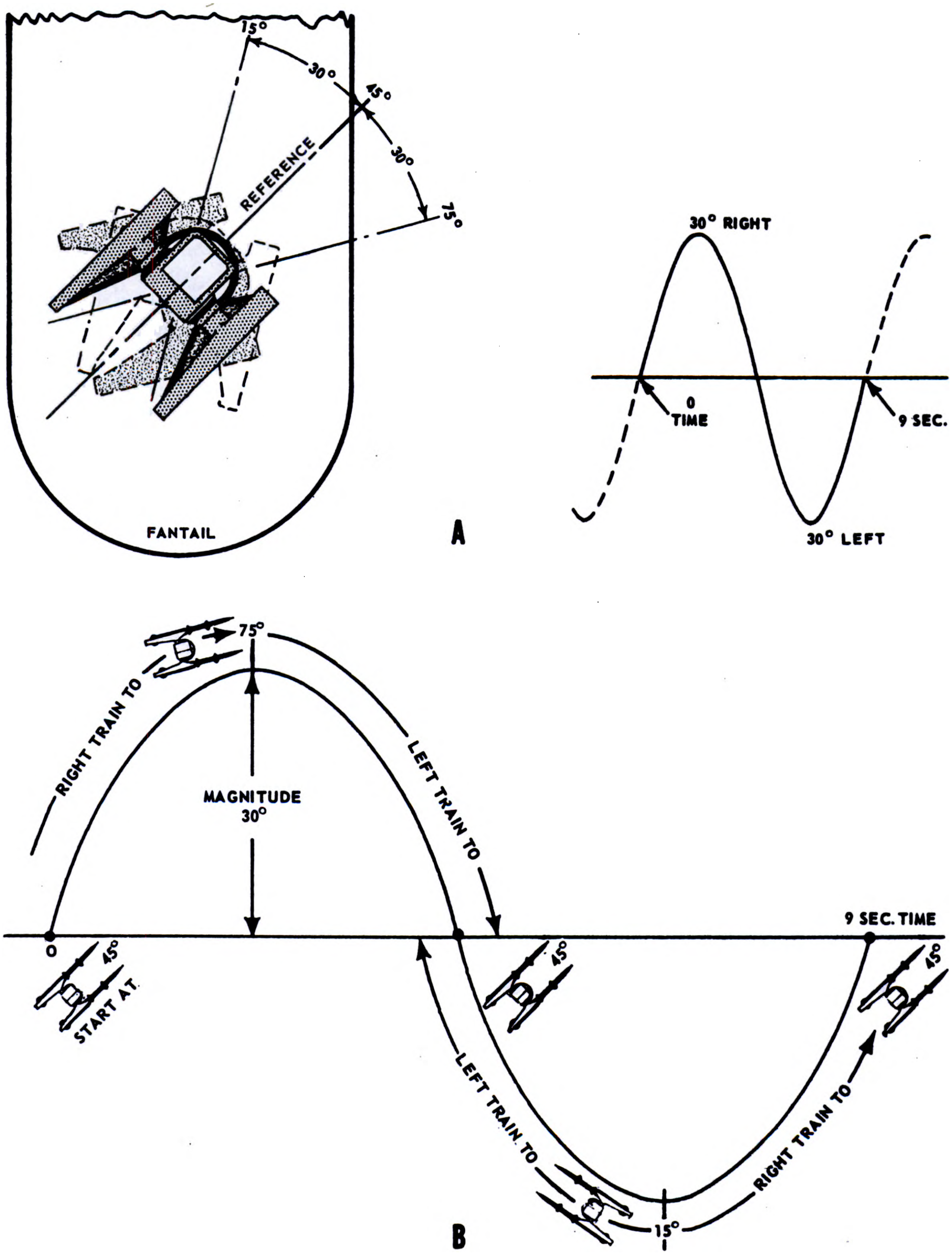
WHEN SHIP'S DECK IS LEVEL, THE GUIDE ARM AND MISSILE WILL POINT IN THE DIRECTION OF THE TARGET

WHEN THE SHIP ROLLS OR PITCHES, IT SWINGS THE GUIDE ARM AND MISSILE OFF TARGET

TO COMPENSATE FOR ROLL AND PITCH OF THE SHIP, THE FC COMPUTER MIXES ROLL AND PITCH CORRECTING SIGNALS WITH LAUNCHER TRAIN AND ELEVATION POSITION ORDERS. THE ROLL AND PITCH PORTION OF LAUNCHER ORDERS KEEPS GUIDE ARM ON TARGET DESPITE SHIP MOTION. ROLL OR PITCH VOLTAGE CAN BE REPRESENTED BY A SINE WAVE: ∿

83.136

Figure 11-47.—Effects of ship's roll and pitch on launcher line of fire, and corrected line of fire.



83.137:138

Figure 11-48.—Simple harmonic motion (SHM): A. Motion of launcher in response to SHM signal describes a sine wave; B. The magnitude, period, and reference pf SHM signal.

director to generate a 30° magnitude, 9-second period SHM signal. After the launcher is synchronized to the 45° reference, the test can begin. The launcher will train to 75° and reverse direction. It rotates through the 45° point and continues on to 15°. Then it reverses direction again and proceeds to 75°. This oscillating motion will continue until we secure the test.

Did you notice that the SHM signal and the motion of the launcher describe a sine wave? The period of an electrical sine wave is the time it takes to complete one full cycle. The same principle holds true for our SHM signal and launcher motion. In response to the dummy director's signal, it takes the launcher 9 seconds to move a full cycle (15° to 75°). That type of signal simulates the kind of roll the ship might experience in ground swells. Of course, you can select higher (faster) periods to simulate rougher sea conditions. Therefore, SHM signals are used to check how accurately a power drive follows this type of input signal. The error trace on the error recorder indicates how well the servosystem performs under these conditions. If the power drive under test performs perfectly, a straight line shows up on the error trace. A straight line indicates that there is no error between the input signal (SHM) and the servosystem's output (response). In practice, you will never get a perfectly straight line. However, the trace should be close to one.

Constant Velocity Signals

The constant velocity (CV) signal simulates the kind of power drive order which is produced when the FCS is tracking a target. Refer to figure 11-49. Let's assume the FCS radar is tracking the target. The director must rotate (train) at a rate of 10°/second velocity to keep the radar's beam or line of sight (LOS) on target. When synchronized to the FCS order, the launcher also must rotate (train) at the same velocity to maintain its LOF. If the director's velocity remains constant for a period of 5 seconds, it will have traveled a total of 50°. To remain synchronized with the FCS order, the launcher also must rotate the same distance in the same period of time.

The dummy director is capable of simulating such constant velocity orders. Instead of a back-and-forth motion as simulated with an SHM signal, a CV signal drives the launcher in one (selected) direction only. The launcher moves at the selected velocity rate and continues driving

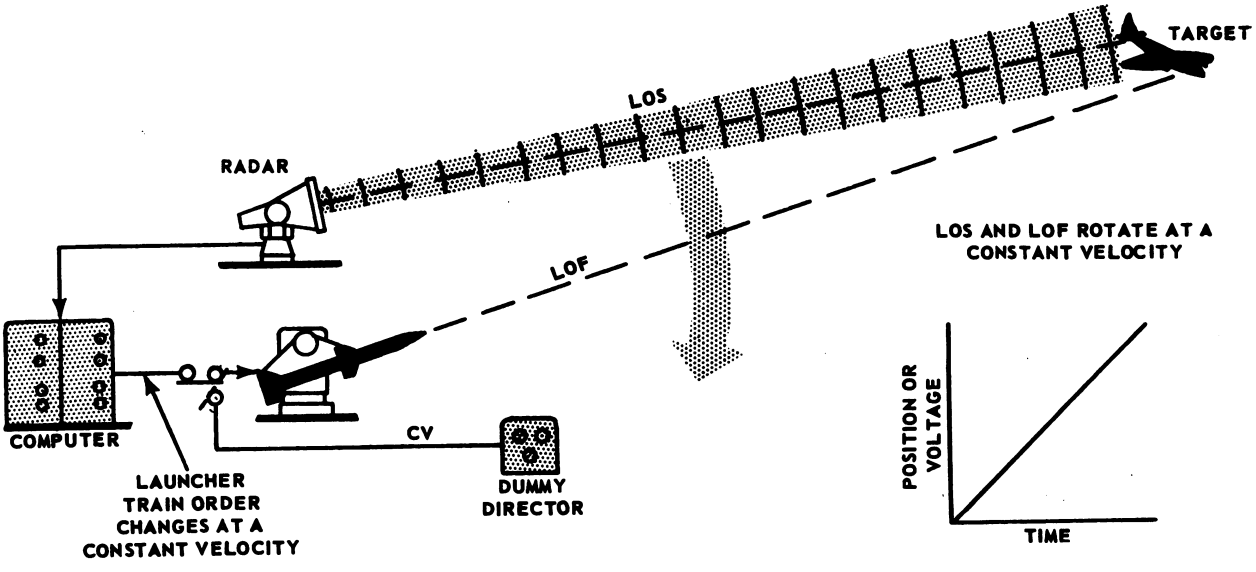

TARGET
LOS
RADAR
LOF
LOS AND LOF ROTATE AT A CONSTANT VELOCITY
POSITION OR VOLTAGE
TIME
COMPUTER
CV
LAUNCHER TRAIN ORDER CHANGES AT A CONSTANT VELOCITY
DUMMY DIRECTOR

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Figure 11-49.—Following constant velocity signals.

until the test is secured. If the power drive under test performs perfectly, a straight line shows up on the error trace. That indicates there is no error between the CV signal and the launcher response. In practice, the trace should be fairly straight.

Fixed Displacement Signals

You recall that a launcher has several fixed positions (stow, load, and so on) to which it must drive. These position signals are generated by the GMLS's fixed position synchros (1X and 36X CXs). Also, during fixed position orders, only the primary portion of the servosystem is used. The velocity (and integration) system(s) are deactivated at this time.

Usually, a fixed displacement (FD) order creates a large instantaneous error for the launcher. Its servosystems must reduce this error quickly and accurately. A dummy director is capable of simulating a fixed displacement position order (figure 11-50). If the power drive under test performs properly, the error recorder produces a trace similar to the one in the figure. It represents the acceleration, driving velocity, and deceleration periods/phases of the servosystem's reaction. In practice, you should receive a trace fairly close to the one shown.

REFERENCES

The following reference materials were used to develop the information presented in this chapter.

1. NAVEDTRA 10199-C, *Gunner's Mate M 3 & 2*

2. NAVEDTRA 10200-D, *Gunner's Mate M 1 & C*

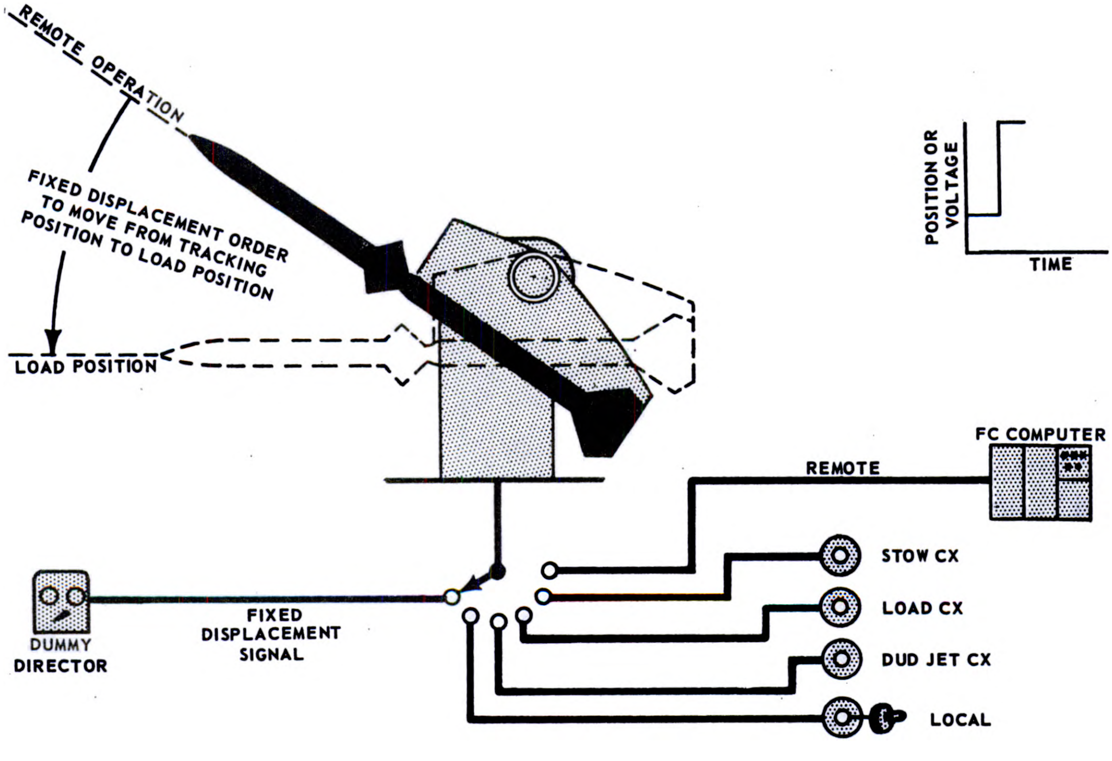

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Figure 11-50.—Fixed displacement signal.

3. NAVEDTRA 10185-C, *Gunner's Mate G 3 & 2*

4. NAVEDTRA 10186-D1, *Gunner's Mate G 1 & C*

5. NAVEDTRA 10224, *Fire Control Technician M 3*

6. NAVEDTRA 10207-B, *Fire Control Technician G 3 & 2*

7. NAVEDTRA 10559, *IC Electrician 3*

8. Navy Electricity and Electronics Training Series (NEETS), Modules 1, 3, and 15

9. SW394-AC-MMA-050/LS10, *Guided Missile Launching System, Mk 10 Mod 0*

10. NAVSEA OP 4470, *Guided Missile Launching System, Mk 13 Mods 4, 5, 6, and 7*

CHAPTER 12

EXPLOSIVES, DEMOLITION, AND PYROTECHNICS

As a Gunner's Mate, you will be required to maintain, stow, and handle many different components that contain explosive material. These items include missiles, rockets, gun ammunition, small arms ammunition, demolition materials, and pyrotechnic devices. The information presented in this chapter is designed to familiarize you with explosives. We will discuss their characteristics and classifications.

NAVSEA OP 4, *Ammunition Afloat* and NAVSEA OP 5, *Ammunition and Explosives Ashore* are excellent reference sources. They discuss individual explosives and give safety regulations for handling, stowing, producing, renovating, and shipping these materials. You should become familiar with these publications.

NAVSEA OP 2212, *Demolition Materials* and SW050-AB-MMA-010 (formerly NAVSEA OP 2213), *Pyrotechnic, Screening, and Marking Devices* are two more excellent reference sources. They discuss the demolition and pyrotechnic devices, materials, and equipments used by the Navy, and provide instructions for their safe and effective use. Become familiar with these publications also.

EXPLOSIVES DEFINED

The term "explosive" applies to materials that either detonate or deflagrate. Detonate means to explode with sudden violence. Deflagrate means to burn rapidly, producing intense heat and sparks. An explosive material can be created from a wide variety of chemical compounds or mixture of substances. When this material is subjected to a suitable initiating impulse or agent, it undergoes a rapid chemical and physical transformation.

The initiator may be flame, sparks, heat, impact, or friction. It can also be applied mechanically or electrically. The term transformation is defined as a reaction (chemical), decomposition (breakdown), or change. The transformation of an explosive material can range from extremely fast to virtually instantaneous. The result of this rapid decomposition is a very sudden and high increase of pressure in the surrounding medium. The decomposition of an explosive material accomplishes work. This work may either be useful or destructive in nature and depends on the measure of control exercised over the reaction.

Military explosives are divided into two general classes— high and low explosives. The main distinction between them is their rate of decomposition.

HIGH EXPLOSIVES

A high explosive is characterized by the extreme rapidity of its decomposition. Once initiated, a high explosive transforms from its original form and composition almost instantaneously throughout its total mass. The reaction is accompanied by the rapid evolution of a large volume of gas and heat. This causes a very high pressure and widespread shattering effect. High explosives are often further classified as primary or secondary explosives. This depends upon their sensitivity to initiation. Primary explosives are those that are very sensitive. Secondary explosives are those that are relatively insensitive. Primary explosives are also referred to as initiating explosives.

LOW EXPLOSIVES

Low explosives are mostly solid combustible materials that decompose rapidly but, normally, do not explode. This action is known as deflagration. The low explosive is usually ignited by flame and its speed of combustion is fixed or controlled. The size of the powder granules, the density of loading, the confinement (surrounding pressure), and other similar factors govern the rate of combustion. Combustion occurs steadily over the surface of the powder grains and from layer to layer until the total mass is consumed. The resultant reaction causes evolution of heat and usually a large volume of gas.

The distinction between low and high explosives is not sharply defined as both terms are relative. Some low explosives under certain conditions, may detonate when ignited. Conversely, some high explosives may simply burn if ignited under the proper conditions.

CLASSIFICATION OF EXPLOSIVES

Explosive substances may be classified by their reaction, composition, or service use. The terms "high explosives" and "low explosives" serve as a means of classifying explosives by their reactions. By composition, explosives are classified as explosive mixtures or explosive compounds. Explosive mixtures are made up of distinct substances that are carefully prepared and mechanically conglomerated (mixed) in varying proportions. These mixtures must have some oxygen supplier and a combustible also. Explosive compounds are homogeneous (similar) substances that contain within themselves the oxygen, carbon, and hydrogen necessary for combustion.

When explosives are classified by their service use, they are identified as propellants, initiating explosives, auxiliary explosives, and burster (or main) explosives. This is how they are used in the ordnance materials you, as a GM, will most likely encounter.

Propellants

The primary function of a propellant is to provide pressure. The pressure acts against the object to be propelled and will accelerate it to a required velocity. This pressure must be controlled so that it will not exceed the design pressure of its container. In addition, the propellant explosive must be insensitive to shock. Propellants may be in either solid or liquid form and are considered low explosives. Solid propellants have been developed for use in rockets, missiles, and similar devices. Liquid propellants are currently used in torpedoes and certain missiles to provide their propulsive and accessory power.

Initiating Explosives

The initiation of an explosive reaction requires the application of energy in some form (e.g. flame, shock, etc.). The device used to initiate the burning of a propellant explosive is called a primer, initiator, or squib. When fired, the primer produces the long, hot flame required to ignite the propellant. The device used to initiate the reaction of a disrupting- or demolition-type explosive is called a detonator. When fired, the detonator produces the shock necessary to initiate the explosive reaction.

Auxiliary Explosives

Large propellant charges and relatively insensitive explosives require an intermediate charge. The flame or shock of the initiating explosive can then be increased to ensure proper reaction of the main explosive charge. The intermediate or auxiliary explosive used with propellants is called an ignition charge (igniter). It consists of a quantity of flame-producing material sufficient to engulf the propellant grains. The auxiliary explosive used with burster explosives is called a booster. It consists of a quantity of high explosive more sensitive than the burster charge. The booster increases the shock of the detonator to a degree sufficient to explode the burster charge.

Burster Explosives

Burster explosives are the least sensitive of all explosives. They are often used alone or as part of the main explosive charge for warheads and other bomb-type ammunitions. Although insensitive, burster explosives produce the greatest shattering effect and are always classified as high explosives. The shattering power of an explosive is termed "brisance."

CHARACTERISTICS

To better understand explosives, you should become familiar with the characteristics of an explosive reaction. Some of these characteristics are factors in determining the suitability of an explosive for military use.

Sensitivity

The sensitivity of an explosive material is a very important characteristic. It is considered when a particular explosive is selected for a specific task. It is also critical when it comes to the safe handling and use of an explosive.

Sensitivity is a measure of the amount of energy required to initiate an explosion. It determines the amount and type of force (or energy) necessary to cause reliable detonation. This force or energy can be in the form of heat, flame, sparks, shock, and/or friction. If a substance within an explosive compound is so sensitive that it cannot withstand even the slightest blow, this explosive can have no practical application. Primary high explosives (mentioned earlier) are very sensitive and are often used as primers. However, they are not that sensitive to be unsafe for military use.

Stability

The stability of an explosive is its ability to withstand adverse conditions and deterioration while in stowage or use. Stability is important in determining the length of time an explosive can be kept under normal conditions. Generally speaking, a good explosive should withstand reasonable exposure to such extremes as high humidity in a hot climate or cold temperatures of arctic conditions.

Ignition Temperatures

There is no one temperature that causes an explosive to ignite or detonate. Its behavior when heated depends on two factors—the manner of confinement and the rate and manner of heating. It is usually possible to find a small range of temperatures that will cause a given explosive to ignite or detonate. These ignition/explosion temperatures are useful in setting safe limits. When an unconfined explosive is heated sufficiently, it will usually catch fire and burn. However, detonation can occur either immediately or after an interval of burning. Generally, the likelihood of detonation rises rapidly with increasing confinement. This is due to the resultant rise of pressure.

Loading Properties

The adaptability of an explosive to loading requirements is an important factor in fixing the explosive's usefulness. For press loading, a granular explosive must be used. For cast loading (pouring into a mold), an explosive having a relatively low melting point is required.

Explosive Reaction

An explosive reaction is characterized by its velocity, heat, gases, and pressure.

VELOCITY.—An explosive reaction differs from ordinary combustion in the velocity of its reaction. The combustion velocity of an explosive may vary within rather wide limits. This depends on the explosive substance and its physical state. The combustion velocity of a propellant also depends upon its composition. If it is a solid propellant, the size and shape of the propellant grains affect the velocity. For liquid propellants, the fineness of the spray droplets affects the velocity.

HEAT.—An explosive reaction is always accompanied by the rapid liberation of heat. The amount of heat represents the energy of the explosive and, hence, its potential for doing work.

GASES.—An explosion reaction is also always accompanied by the release or emission of various gases. These include carbon monoxide, carbon dioxide, hydrogen, hydrogen cyanide, methane, nitrogen oxides, and water vapor. Many of these gases are suffocating and poisonous (toxic).

Generally, commonly used high explosives produce a large proportion of harmful gases. They are particularly dangerous because, under normal conditions, they do not rapidly dissipate. The gases produced from low explosives are rarely dangerous. They usually escape into the atmosphere and are quickly dissipated or diluted with the environment.

Some of the gaseous byproducts created by an explosive reaction are themselves flammable. Occasionally they form explosive compounds within the air. Especially dangerous gases include carbon monoxide, hydrogen, and methane.

PRESSURE.—An explosive reaction creates pressure. This is due to the formation of gases which are expanded by the heat liberated from the reaction. The work performed by an explosion is proportional to the volume of gases and the amount of heat released.

The maximum pressure developed and the manner in which this energy is applied are also based on the velocity of the explosive reaction. When the reaction is of low velocity, the gases receive heat while being evolved. The maximum pressure of the explosion is achieved rather late in the reaction. When the reaction is of high velocity, the maximum pressure is reached sooner and is greater. A brisant explosive achieves its maximum pressure very rapidly and shatters the material surrounding or in contact with it.

Effects of Explosions

Military weapons inflict damage on a target or target area by the force of their explosion. Specifically, this force is created by the expanding gases and thermal effects.

Expanding gases develop a damaging shock wave throughout the surrounding medium. The medium can be air, water, earth, or a combination of these. Expanding gases can fragment the case or container of the explosive. Pieces of the case (shrapnel) are propelled in all directions. Sometimes, special materials within the case are also propelled outward (e.g. the continuous rod warhead). Expanding gases can also create secondary missiles by hurling other objects within the target area.

Damage inflicted by the thermal effects of an explosion is simply the damage caused by heat.

The damaging effects of an explosion are obviously very important in the military role. However, other factors must also be considered when choosing a particular explosive.

The explosive must be efficient. Efficiency is expressed in terms of the total energy exerted and the time within which it occurs. The most efficient explosives are those that are both powerful and brisant.

The military deals in large quantities. Therefore, the raw materials necessary for our explosives must be in abundant and available supply. And don't forget the economic side of house. Production of an explosive must be cost effective and competitively priced. However, should a particular explosive have superior characteristics, it may be procured at higher costs. If you just have one shot at an incoming target, you'll want the best money can buy!

Nuclear Explosives

Nuclear weapons are part of the Navy's weapons system. As a gunner's mate, you may be assigned to a nuclear weapons handling team. The team transfers these weapons between combatant ships and maintenance activities. You may also be assigned to a maintenance shop aboard a tender or weapons station. Here, you will assemble, disassemble, test, and perform maintenance on nuclear weapons.

Your duties and responsibilities toward nuclear weapons require that you know the potential hazards involved. You must be very knowledgeable of the precautions that must be taken, especially those dealing with safety and security.

Before being assigned to duties involving nuclear weapons, you will be given extensive training. This training will cover the skills necessary to work with these weapons, plus the explosive and radiation hazards involved.

Maintenance, handling, and safety precautions for nuclear weapons are presented in special weapons ordnance publications (SWOPs) for each weapon. For more information on the types of nuclear explosions, radiation, and their effects, see NAVEDTRA 10054-E, *Basic Military Requirements*.

SERVICE EXPLOSIVES

Explosives suitable for military operations are generally called service explosives. They are manufactured under strict specifications and are often used by more than one branch of the armed forces. These explosives are constantly being revised and improved. We will briefly describe the basic characteristics of explosives that you may encounter. They are listed in alphabetical order for your convenience.

Amatol

Amatol is a mixture of ammonium nitrate and TNT with a density of 1.6. The ratio of 80-20 amatol (80 percent ammonium nitrate and 20 percent TNT) will not melt. Its color varies from a light straw to dark brown. Because amatol contains ammonium nitrate, it is hygroscopic. (Hygroscopic means the material will pick up or absorb moisture in the air which reduces the explosive's sensitivity.) It must be kept in an airtight container. If properly packed, amatol may be stored for long periods of time with no change in sensitivity, brisance, or stability. It may corrode steel when dry and, in the presence of moisture, it attacks copper and bronze.

Ammonium Nitrate

Ammonium nitrate varies in color from white to light brown. It has a melting point of 338°F and a density of 1.3. It is the least sensitive of service explosives and must be initiated by a booster charge to successfully detonate.

Ammonium nitrate is extremely hygroscopic and must be packed in an airtight container. Ammonium nitrate or composite explosives containing ammonium nitrate are not suitable for use underwater. If so used, they must be packaged in a waterproof container or detonated immediately after emplacement.

Ballistite

Ballistite is double-base powder used as a rocket propellant. It burns with a considerable amount of flash and smoke, and generates a great volume of gas. Ballistite burns progressively but at a slower rate than gunpowders. The rate of burning is dependent upon three factors:

1. The composition and physical characteristics of the powder grain.
2. The temperature of the powder grain before ignition.
3. The pressure during reaction.

Ballisite is produced in various shapes to fit the rocket motor housing. It is ignited by the flash of a black powder charge which, in turn, is ignited electrically. Obvious disadvantages are the telltale flash and black smoke.

Black Powder

Black powder is the oldest explosive and propellant known. It consists of a mixture of potassium or sodium nitrate with charcoal and sulfur. The chemical stability of black powder is practically unlimited when stored in an airtight container. However, it deteriorates irregularly when exposed to moisture.

Black powder is not affected by moderately high temperatures. It is not subject to spontaneous combustion at ordinary stowage temperatures. However, it is highly flammable and very sensitive to friction, shock, sparks, and flame. When ignited, it is extremely quick and violent in its reaction.

The use of black powder has decreased with the development of new chemical compounds which are replacing it in many applications. But, if smoke is no objection, black powder is still considered by many to be the best substance available for producing and transmitting a quick, hot flame.

Composition A-3

Composition A-3 is a mixture of 91 percent RDX and 9 percent wax. The wax coats the RDX particles, desensitizes them, and acts as a binder. Composition A-3 varies in color from white to buff and is not adversely affected by moisture. It has a melting point of 392°F to 446°F with a density of 1.6.

Composition B

Composition B is a mixture of approximately 60 percent RDX, 39 percent TNT, and 1 percent wax. It is more sensitive than TNT. Because of its shattering powder and high rate of detonation, composition B is used as a main charge in shaped charges. Composition B is not adversely affected by water.

Composition C-4

Composition C-4 is a mixture of 91 percent RDX and 9 percent nonexplosive plasticizers. This plastic explosive is white in color with a density of 1.6. Composition C-4 will eventually replace composition C-3 as a demolition charge. C-4 is also used as a burster or main explosive charge. It is brisant and moldable over a wide range of temperatures (−70 °F to +170 °F). C-4 is stable and less subject to erosion when used for underwater demolitions.

Diazodinitrophenol

Diazodinitrophenol (DDNP) is a yellowish-brown powder. It is soluble in various acids and most solvents, but, it is insoluble in water. (Soluble—capable of being dissolved in a liquid; insoluble—incapable of being dissolved in a liquid.) A cold sodium hydroxide solution may be used to destroy it.

DDNP is desensitized by immersion in water and will not react with it at normal temperatures. It is less sensitive to impact but more powerful than lead azide. The sensitivity of DDNP to friction is approximately the same as that of lead azide.

DDNP is used with other materials to form priming mixtures, particularly where a high sensitivity to flame or heat is desired.

Dynamite

Dynamites and blasting gelatins are explosives procured from commercial sources. Their sensitivity and keeping qualities are of a different order than those of standard military explosives. Therefore, special conditions for handling and stowage are mandatory. Dynamite is more hazardous in stowage than other high explosives because:

1. It may exude nitroglycerin, which is a greater fire and explosion hazard than other types of exudate. (Exude—to ooze out; exudate—exuded matter.)
2. It deteriorates more rapidly than other high explosives. Therefore, it is a policy not to stow dynamite and blasting gelatins in large quantities at naval activities handling other ammunition or explosives, except with specific approval.

Explosive D

Explosive D, also known as ammonium picrate, is a high explosive. In bulk, explosive D appears in the form of finely divided crystals. Explosive D stains human hair and skin yellow. It has two major disadvantages:

1. Because of its high melting point, it cannot be melted and cast. Therefore, it must be loaded by pressing.
2. It can react with certain metals such as lead, potassium, copper, and iron to form sensitive compounds. It must, therefore, be protected from direct contact with such metals.

The color varies from yellow to orange brown. Explosive D is soluble in water and alcohol and has a melting point of 509 °F. Explosive D is nonhygroscopic when dried to a specified moisture content. It is very difficult to detonate and hard to ignite. Explosive D is used primarily as the main charge for large caliber projectiles. While its powers and brisance are slightly inferior to those of TNT, it is much more insensitive to shock. It will stand impact on armor plate without deflagrating. The velocity of detonation is about 21,300 feet per second (fps).

HBX—HBX-1, HBX-3, H-6

The HBX group of explosives is an important segment of the explosives used by the Navy. They all contain a mixture of RDX, TNT, powdered aluminum, D-2 wax, and calcium chloride. These compounds are combined in varying percentages to meet the requirements of their principal use.

The explosive HBX-1 is a cast mixture of the foregoing compositions. HBX-1 is used primarily in mines.

HBX-3 is composed of the same compositions as HBX-1 but in different percentages. HBX-3 is used primarily in mines and torpedo warheads.

H-6, a later development in the family of HBX explosives, is composed of the same compositions as the other HBX explosives. It is used in bombs and missiles and is a cast filler considered superior to the other HBX compositions.

HBX explosives are noncorrosive and chemically stable. Tests indicate that prolonged exposure to unusually high temperatures may cause the loss of a small part of the wax used as a desensitizer. This wax may appear as exudate, but it is not explosive. The melting point of HBX varies from 176 °F to 194 °F. HBX has a velocity of detonation of about 24,300 fps and its color is slate gray.

HMX (Cyclotetramethylene Tetranitramine)

HMX was discovered as a byproduct in the production of RDX. Although it is almost as sensitive and powerful as RDX, it is seldom used alone in military application. It is mixed with a compound such as TNT. In the Navy, HMX is used as an ingredient in plastic-bonded explosives. (If you can quickly pronounce "cyclotetramethylene tetrantramine," go to the head of your class!)

Lead Azide

Lead azide has a high ignition temperature. It is poisonous, slightly soluble in hot water and alcohol, and highly soluble in certain acids. Lead azide reacts with copper, zinc, cadmium, or alloys containing such metals. The reaction forms an azide which is more sensitive than the original lead azide. Lead azide will not react with aluminum. Therefore, detonator capsules for lead azide are made of this metal. The hygroscopicity of lead azide is very low. Water will not reduce its impact sensitivity.

Lead azide may be used where detonation is caused by flame or heat. The velocity of detonation is about 17,500 fps. Its color varies from white to buff. Lead azide has become the most widely used primary explosive in detonators for ordnance type fuzes. It is also used in primary explosives. When protected from humidity, it is completely stable in stowage.

Lead Styphnate

Lead styphnate comes in crystal form. It is particularly sensitive to fire and the discharge of static electricity. When dry, styphnate can be readily ignited by static discharges from the human body. Crystals that are long and narrow are more susceptible to static electricity. Lead styphnate will not react with metals. It is less sensitive to shock and friction than lead azide. Lead styphnate is slightly soluble in water and methyl alcohol. It may be neutralized by a solution of sodium carbonate. The velocity of detonation is about 17,000 fps and the color of lead styphnate varies from yellow to brown. Lead styphnate is used as a component in primer and detonator mixtures.

Nitroguanidine

Nitroguanidine is a powerful high explosive. When incorporated into propellants, the propellant burns at a very low temperature. The result is no muzzle flash when a gun is fired.

Nitroguanidine, under moderate temperature and humidity, is acceptably stable. It is comparable in strength to TNT but its sensitivity is somewhat less than that of TNT. The velocity of detonation of nitroguanidine is about 24,400 fps. The color is white to yellowish.

Plastic Bonded Explosives (PBXs)

PBXs are relatively new types of explosive compositions that have found increased use in naval weapons. They are generally made of an explosive compound (like RDX or HMX) incorporated into a plastic binder. PBXs were used initially in warheads for weapons carried externally on high-speed aircraft. New PBX formulations, designed especially for underwater weapons, have substantially higher damage capability than the old HBX-type explosives. PBXs are now used in almost all new underwater weapons.

Pentolite

Pentolite is a mixture of PETN and TNT. Its color varies from white to yellow. A mixture of 50-50 pentolite (50 percent PETN and 50 percent TNT) has a high power and detonation rate. It is often used as a booster charge in certain models of shaped charges. Pentolite is not adversely affected by moisture and is moderately stable. However, it will react slightly with magnesium, steel, copper, and brass, but not with aluminum or stainless steel. Pentolite has a melting point of 169 °F and a density of 1.6.

PETN

PETN is a white granular powder and is highly sensitive. It is one of the most powerful military explosives. PETN is not adversely affected by water. Moist PETN reacts to some extent with most metals except aluminum and stainless steel. However, most metals are unaffected by dry PETN. It is used primarily in mixture with other explosives. As the core of detonating cord, PETN is combined with a small quantity of wax to desensitize and lubricate it. PETN is nearly insoluble in water and may, therefore, be used in underwater demolitions. PETN has a melting point of 286°F and a density of 1.6.

RDX

RDX is a white, crystalline powder with a melting point of 396°F. It is another very powerful, highly sensitive, and brisant explosive. RDX is used primarily in the composite explosives such as composition C-4. RDX is also used alone in some electric and nonelectric blasting caps.

Smokeless Powders (SPs)

These are low explosives which are used to give a specified velocity to the delivery of weapons such as gun projectiles, rocket projectiles, torpedoes, and depth charges. Relatively slow, controlled decomposition is required to provide time for the force of the evolved gases to act without the destruction of the projecting equipment.

The basic component of modern smokeless powder is vegetable fiber (generally cotton), molded into grains and dried. The resulting powder is a low explosive which burns instead of detonating. It is used almost exclusively as the propellant for gun and rocket ammunition. The powder is generally of three types: single-base, double-base, and triple-base.

Smokeless powder is obviously a more effective propellant than black powder. It is far less sensitive, tricky, and dangerous to handle. It has the following characteristics:

1. It burns evenly.
2. It is noncorrosive and will not react to metals.
3. It gives off large quantities of gas during burning, which is highly desirable in a propellant.
4. It leaves little residue or ash.
5. It is somewhat hygroscopic and tends to deteriorate as it becomes moist.

There are certain explosive ingredients in smokeless powder which tend to evaporate when the powder is exposed. It must, therefore, be stowed in air-tight, moisture-proof containers.

Excessive heat has an unfavorable influence on the stability of smokeless powder. At temperatures below 60°F, the stability is not appreciably affected. The rate of decomposition begins to rise at temperatures above 70°F, becoming relatively high at 100°F. Decomposition dangerously accelerates at temperatures above 110°F. Precautions must, therefore, be taken to ensure the maintenance of a uniformly low temperature in magazines where smokeless powder is stowed.

The various index designations of smokeless powders are: SPC, SPCA, SPCF, SPCG, SPD, SPDB, SPDF, SPDN, SPDW, SPR, and SPW. They are described in the current edition of NAVSEA OP 4 volume 1, *Ammunition Afloat*. (Note: This publication may soon be replaced by SW010-AB-GTP-010.)

Tetracene

Tetracene is a colorless or pale yellow material. It is soluble in strong hydrochloric acid. It is practically insoluble in alcohol, water, benzene, ether, and carbon tetrachloride. Tetracene is only slightly hygroscopic. It explodes readily from flame and produces a large volume of black smoke.

Tetrytol

Tetrytol is a cast mixture usually of 70 percent tetryl and 30 percent TNT. Its color is yellow with a density of 1.6 and a melting point of 169°F to 248°F. Tetrytol is about twice as sensitive as TNT. It is not adversely affected by moisture and possesses satisfactory stowage properties. Tetrytol reacts slightly with most common metals. It is more effective than TNT as a cutting charge in demolition work.

TNT

TNT's chemical name is trinitrotoluene (tri-ni-tro-tol-u-ene). TNT is the most common military explosive. It can be found in granular, flake, pressed, or cast form. Its color varies from straw to yellowish brown.

TNT is not affected by moisture and is very stable in stowage. It is highly toxic and relatively insensitive. TNT is used as a standard explosive (1.00 density) against which other military high explosives are rated.

DEMOLITION MATERIALS

Before going into the subject of demolition, it must be emphasized that the information presented here WILL NOT qualify you as a demolition expert. Demolition skills are only acquired through specialized and intensive training. Never attempt to tamper with any demolition material—the result could be disastrous.

So, as Gunner's Mates, where do we get involved with demolition materials? Apart from those rare assignments to a Seabee unit, EOD, UDT, etc., the ships we are stationed on receive demolition kits. These kits may then be used in the event the ship must be abandoned. Emergency destruct charges will be placed to destroy classified materials, special equipments, and nuclear weapons. They can also aid in scuttling the ship. All these actions are intended to deprive an enemy access to or use of the sensitive items vital to national security.

You will primarily be responsible for the safe handling, stowage, maintenance, and (sometimes) the use of demolition materials. The information presented in this section is intended to only familiarize you with demolition materials and terms in general. If you are required to actually use demolition materials, you will receive additional training in this area.

The reference source on demolition is NAVSEA OP 2212, *Demolition Materials*. It describes the various devices, explosives, and hardwares used in demolition work. Instructions and technical information pertaining to the use of demolition materials are also presented in OP 2212. NAVSEA OP 4 and OP 5 are two more good sources for this topic subject.

IDENTIFICATION OF DEMOLITION MATERIALS

The term "demolition materials" refers to certain explosive charges, incendiaries, and related accessories. These items are deliberately and manually placed or set around the material to be destroyed. This work can be performed by an individual (which is the preferred method) or by a group/team. Demolition materials are used for the express purpose of destroying or altering man-made or natural objects and obstacles.

Demolition equipment is identified by its approved nomenclature and designation number. A contract number, place and date of manufacture, a lot number, and net weight are other identifiers. This information will be stenciled either on the item or its shipping container; usually on both.

Demolition items designed and produced under Navy contract are assigned a mark and mod number. Demolition items under Army contract and used by the Navy retain their Army designation. For example, the M1A1 (M for mark, A for mod) bangalore torpedo demolition kit.

DEMOLITION EXPLOSIVES

Demolition explosives are U.S. military explosives (another name for "service explosives"). In addition to being used as the main component of a demolition charge, they are used in the initiators and primers. These explosives are generally manufactured under strict military specifications. Commercial and, sometimes, foreign explosives are used, but they are limited in application. (Dynamite is one such commercial explosive.)

Explosives suitable for demolition operations must have the following characteristics:

1. Produced from readily available raw materials and be inexpensive to manufacture.
2. Relative insensitivity to shock or friction, yet able to be positively detonated by easily prepared initiators.
3. Shattering effect (brisance) and potential energy adequate for the purpose.
4. Stability adequate to retain usefulness for a reasonable time when stored in any climate at temperatures between −80°F and +165°F.

Table 12-1.—U.S. military explosives

EXPLOSIVE	TYPICAL USES	VELOCITY OF DETONATION (FEET-SEC)	RELATIVE EFFECTIVENESS AS AN EXTERNAL CHARGE (TNT = 1.00)	INTENSITY OF POISONOUS FUMES	WATER RESISTANCE
Amatol	Bursting charge	14,800 fps	1.20	Dangerous	Poor
Ammonium Nitrate	Cratering charge, and composition explosives	3,600 fps	0.42	Dangerous	None
Black Powder	Time blasting fuse	1,300 fps	0.55	Dangerous	Poor
Composition A-3	Booster charge and bursting charge	26,900 fps	1.35	Dangerous	Good
Composition B	Bursting charge	25,600 fps	1.35	Dangerous	Excellent
Composition C-4	Demolition charge	26,500 fps	1.26	Dangerous	Excellent
HBX-1	Demolition charge	24,300 fps	Air 1.48 Underwater 1.68	Dangerous	Excellent
HBX-3	Demolition charge	24,300 fps	Air 1.48 Underwater 1.68	Dangerous	Excellent
Pentolite 50/50	Booster charge and bursting charge	24,600 fps	1.26	Dangerous	Excellent
PETN	Detonating cord, blasting cap, and demolition charge	26,000 fps	1.45	Dangerous	None
RDX	Blasting caps, composition explosives	27,400 fps	1.60	Dangerous	Excellent
Tetrytol 75/25	Demolition charge	23,900 fps	1.22	Dangerous	Excellent
TNT	Demolition charge, and composition explosives	22,500 fps	1.00	Dangerous	Excellent

5. High density (weight per unit of volume).

6. Suitability for use underwater or in damp climates.

7. Minimum toxicity (poisonous effects) when stored, handled, and detonated.

8. Convenient size and shape for packaging, stowage, distribution, handling, and emplacing by troops.

9. High energy output per units of volume.

These characteristics are used as an aid in selecting an explosive for a particular job. Table 12-1 lists common U.S. military explosives used in demolition work and their vital statistics. Selection is normally based on relative power. Explosives with a high velocity of detonation are the best for cutting and breaching operations.

Those with a lower velocity of detonation are best for cratering, ditching, and quarrying operations.

TERMS USED WITH DEMOLITION OPERATIONS

The following terms are closely associated with demolition explosives and equipments. You have already been exposed to some (brisance, high and low explosives, detonation, deflagration, etc.). Study these new terms carefully. They are also listed in alphabetical order for your convenience.

ACCESSORIES—Explosive accessories are such things as blasting caps, detonating cords, fuses, initiators, and firing devices. They are used with inert accessories to set off main charges. Inert accessories are nonexplosive items and devices. They include power cable, firing wire, priming adapters, charge containers, and blasting machines.

ACTIVATED—The term "activated" is applied to a demolition charge or a landmine that has been set for booby trap action with a fuze or firing device.

ARMED—The term "armed" applies to a fuze or firing device that has been made ready to be activated by being treated in a particular manner. When arming has taken place, detonator safety and the effects of any safety switches or safety pins have been removed.

BLASTING CAP—A blasting cap is a small cylindrical detonator containing one or more highly sensitive explosives at one end. Blasting caps can be initiated either electrically or from a spit of flame.

An electric blasting cap contains a base load of a high explosive, a primer charge, and an igniter. The firing element consists of two leg wires connected by a bridge wire which is imbedded in the igniter. When electric current is applied to the bridge wire, it heats up and activates the blasting cap's igniter.

A delay electric blasting cap has a burning delay train between the first flash compound and the initiating explosive.

A nonelectric blasting cap is a metal cylinder filled to approximately two-thirds of its length with small explosive charges. They consist of an ignition charge, a priming charge, and a base charge. The end with the unfilled space can be fastened to a fuse or the coupling base of a firing device. A spit of flame from the firing device or fuse initiates the ignition charge.

CRATERING CHARGES—Cratering charges are those explosives which are used for removing large quantities of earth. They operate by producing a relatively slow pushing action.

DEMOLITION CHARGE—A demolition charge is any hand-placed explosive used for a blasting or shattering effect. A standard demolition charge has a threaded activator well into which a blasting cap can be fitted.

External charges are placed on or secured to the outside surface of the object or obstacle to be demolished or altered. Internal charges are placed in naturally occurring cavities or man-made holes in the object or obstacle to be demolished or altered.

DEMOLITION OUTFIT—A demolition outfit is any combination of explosive and nonexplosive accessory items that provides the desired demolition effect. A demolition outfit is also called a demolition kit.

DETONATION, ORDER OF—Order of detonation relates to the relative speed and completeness of the detonation. A high-order detonation is one in which total reaction occurs at maximum velocity. If the reaction is less than total or if velocity is less than maximum, the explosion is said to be a low-order detonation. Variations may be caused by temperature, moisture, and the density of loading. The type of initiator or booster used is also a factor.

DETONATION, RATE OF—The rate or velocity of detonation is the speed at which the explosive reaction progresses through the explosive. In explosive charges, this rate is normally expressed in feet per second. It varies directly with the density of loading, provided all other factors are constant.

DETONATOR—The term "detonator" is loosely applied to demolition components or devices used to initiate explosive action by any means.

DETONATING CORD—Detonating cord is flexible tubing containing a core of high explosive. The material of the core carries the detonation from one end of the cord to the other.

DETONATOR SAFE—"Detonator Safe" is a term applied to the condition of a demolition device. "Safe" is when the igniting element is in some way blocked or separated from the rest of the explosive train.

FIRING DEVICE—The term "firing device" is applied to any device that causes the explosion of demolition charges. The energy from the device is either applied directly to the explosive or to a blasting cap, electric squib, or detonating cord.

An electric firing device is one which uses electricity to initiate the first flash in the explosive train. This leads to the final functioning of the demolition charge.

A mechanical firing device is one in which mechanical motion produces percussion or friction. This energy or force initiates the first flash in the explosive train.

FUSE—A "fuse" is a slow-burning powder-filled cord. It carries flame to an explosive or combustible mass over a predetermined period of time.

FUZE—The word "fuze", which is not to be confused with fuse, is generally applied to mechanical or electrical devices. They usually function over a preset time period to cause detonation, expulsion, or ignition. Typically, the last step in a fuze's functioning is the release of a spring-loaded firing pin which strikes a percussion primer. In demolition work, the term fuze is sometimes used interchangeably with the term firing device.

MAIN FILLERS—Main fillers are high explosives of relatively low sensitivity. They are used as principal explosive charges and constitute nearly all of the bulk of the charge.

POWER OF EFFECTIVENESS—The power or effectiveness of an explosive relates to relative end results. It takes into account such factors as brisance, detonation rate, cratering potential, steel-penetration capability, etc.

PRIMER—In demolition work, the term "primer" sometimes refers to the material used for priming a charge. A percussion primer, which is initiated by a sharp blow as from a firing pin, is sometimes called a primer-detonator.

PRIMING—Priming is the preparation of an explosive charge for detonation.

SHAPED CHARGES—Shaped charges may be cylindrical, linear, or curvilinear. Cylindrical shaped charges are high explosives having a conical glass-filled or metal-lined cavity in one end. The other end has a conical shape with a blasting cap well. Detonation moves from the cap well to the cavity where it is focused to produce a narrow, concentrated force or jet. This so-called "Munroe Effect" is used to bore holes in steel, concrete, and other materials.

Linear and curvilinear shaped charges are generally long and narrow as opposed to cylindrical. They have V-shaped grooves to produce a cutting jet. Shaped charges may be especially fabricated for specific needs.

STAND-OFF DISTANCE—This term refers expressly to the measure of free air space between the base of a shaped charge and the target.

DEMOLITION CHARGES

Demolition charges are high explosives and must be handled with caution. They are classified according to their shape or main purpose. The common demolition charges include:

1. Block charges.
2. Shaped charges.
3. Flexible-linear charges.
4. Explosive sheets.
5. Cable and chain cutters.
6. Military dynamite.

These charges are used for general demolition purposes, emergency destruction, and other special operations. We will limit our discussion to block and shaped charges.

Block Type Demolition Charges

Block charges are prepackaged high explosives used in general demolition operations. They are usually composed of TNT, tetrytol, or composition C-4. They are normally manufactured in the shape of a rectangular block; hence the name block charge.

ONE-POUND TNT BLOCK.—The 1-lb TNT block is commonly issued to ships. It is a general purpose demolition charge, effectively used in cutting or breaching operations. TNT blocks are also insoluble and can be used underwater. These charges are shipped in a wooden box, 50 blocks per box.

The 1-lb TNT block charge consists of two 1/2-pound compressed TNT blocks. They are enclosed in an olive-drab, water-resistant, fiberboard container. See figure 12-1. The container has metal end covers. One of the end covers has an activator or cap well to accept an electric or nonelectric blasting cap. The well is threaded to receive a standard priming adapter.

The 1-lb TNT block can be used as the main charge for a small demolition operation. When necessary, any number of these blocks can be attached together and simultaneously detonated. The 1-lb TNT block can also be used as a booster charge for a major demolition operation.

The TNT may be detonated by special electric or nonelectric blasting caps and detonating cord. After the charge is prepared, a firing device activates the initiator in the cap well. The initiator then detonates the main TNT composition.

MK 2 AND MODS DEMOLITION CHARGE.—The Mk 2 demolition charge is another commonly issued block charge. It is used for general demolition purposes both ashore and underwater. A single charge or any number of charges can be combined for a major demolition operation. The Mk 2 charges are shipped in a wooden box, one per box.

The distinguishing characteristic of a Mk 2 demolition charge is that it consists of 55-pounds

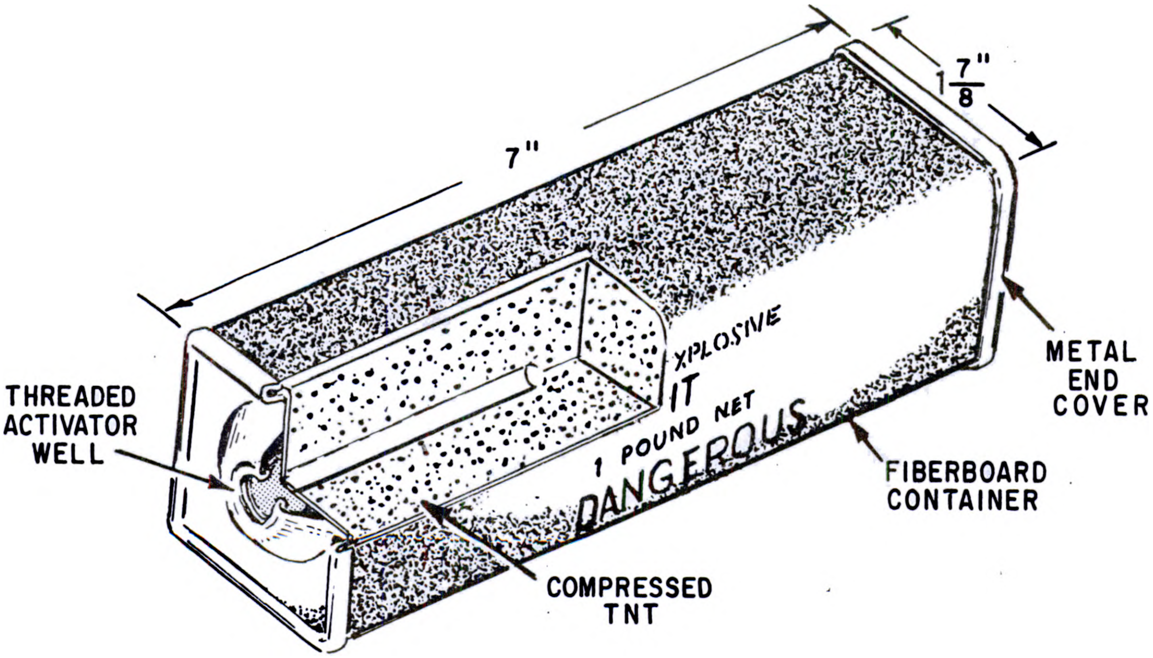

Figure 12-1.—Demolition charge; 1-lb TNT block.

of cast TNT. The explosive is housed in a steel case. (See figure 12-2 for dimensions.) The TNT is poured molten into the case through the filling hole and slowly cooled into a solid form. A cylindrical liner creates a booster cavity within the explosive. The booster charge for a Mk 2 demolition charge is a 1-lb TNT block.

A cover secures the booster in place and has a threaded hole to accept a standard priming adapter. The activator or cap well has a paper seal to protect the booster from dirt, grime etc. The seal must be punctured before the charge can be primed.

A pair of handling lugs are soldered to the case of a Mk 2 Mod 2 charge. They serve as attachment points for line or cable when the charge is lashed in place or lowered into the water. The Mk 2 Mod 3 charge does not have these lugs; that is the only difference between the two mods.

The Mk 2 demolition charge may be primed with a variety of devices. After the charge is prepared, the firing device activates the primer (e.g. blasting cap). The primer activates the 1-lb TNT booster. The booster activates the 55-pounds of cast TNT. These actions are obviously rapid and you end up with a pretty hefty explosion.

Shaped Type Demolition Charges

Shaped charges were previously defined. You will remember that they consist of a conical shaped casing and a quantity of high explosive. The explosive is shaped by a liner to produce a concentrated blast in one direction. As a result, shaped charges have a high penetrating power.

Figure 12-3 shows how the shape of a charge affects the penetrating ability of a blast. All three

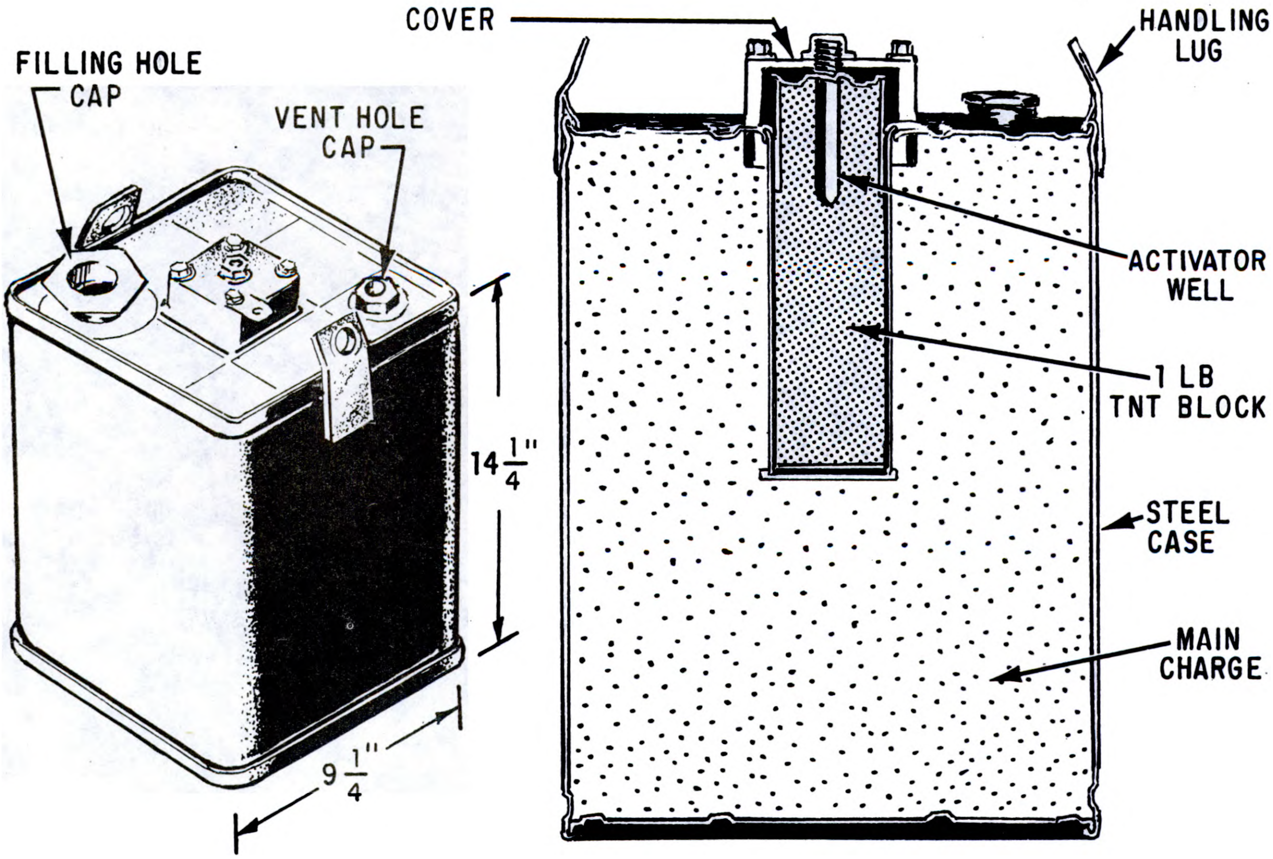

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Figure 12-2.—Mk 2 Mods 2 and 3 demolition charge (55-lb).

of the charges in the figure have the same weight and type of explosive. The flat charge on the left produces an explosive force that is rather evenly distributed over a given target area. This is okay, but produces little penetration.

The shallow-cone shape of the middle charge produces a greater concentration of the explosive force. Penetration of the target is somewhat deeper. The deep-cone shape at the right has concentrated the force of the explosion to actually penetrate the armor thickness. Metallic fragments of the armor can now reach the interior of the target and do more damage (as shrapnel for example).

Besides the depth or angle of the cone, the liner material of a shaped charge can affect its efficiency. If the cavity is lined with a material that can be broken into small pieces or melted, efficiency increases. These small particles are carried by the concentrated explosive jet which is, thus, increased in its weight. The result is a deeper penetration.

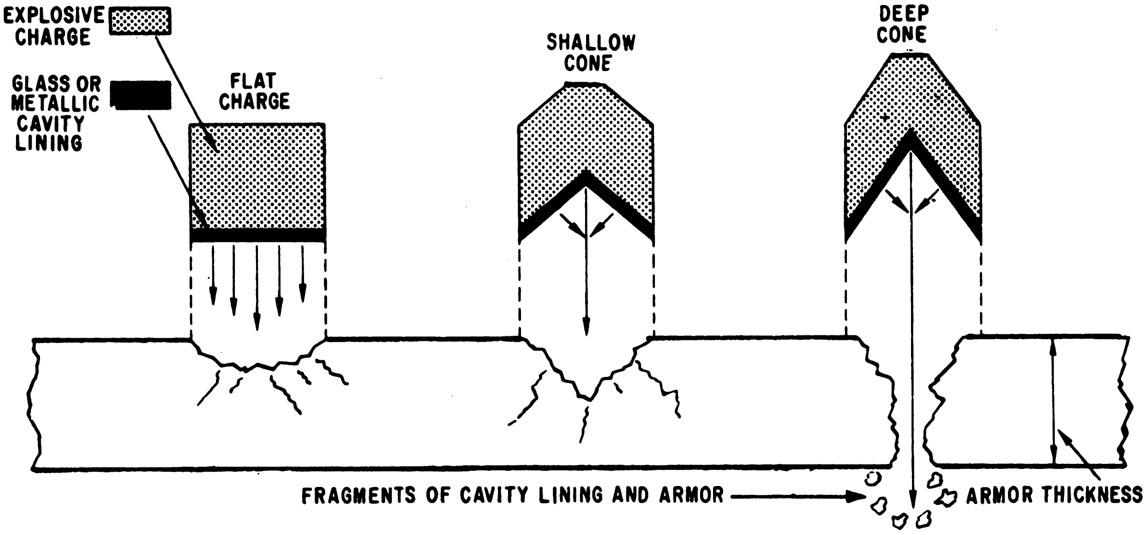
Maximum penetration is obtained when the shaped charge is exploded at an optimum distance from the target. This is called "stand-off." You don't need a tape measure to determine this distance. It is automatically provided by a fiber sleeve or metal legs which support the charge on the target. Maximum effect is produced by a stand-off of one to one-and-a-half times the diameter of the charge.

Some shaped charges have a carrying strap. Besides making it easier to transport the device, the strap is used to hang the charge in a horizontal position against a vertical surface. Shaped charges are not very effective underwater. This is because water occupies the cavity and stand-off area, thus, preventing the high-velocity jet from forming properly.

MK 45 SHAPED CHARGE.—The Mk 45 shaped charge is shown in figure 12-4. It is used in special demolition applications such as the emergency destruction of nuclear weapons. Proper application and position of the charge can be determined by referring to the specific demolition instructions concerning the weapon.

The Mk 45 shaped charge is about 4.5 inches tall and 2 inches in diameter. The waterproof bakelite case and cap contains a 60° cone-shaped RDX pellet and RDX booster. This charge has an integral stand-off spacer and is mounted to the target's surface by nylon pile and hook tape. (This is similar to Velcro material.)

A copper cavity liner enables the charge to penetrate up to 4 1/2 inches into cold rolled steel. An activator or cap well is located at the top of the charge to accept a special electric or


EXPLOSIVE CHARGE
GLASS OR METALLIC CAVITY LINING
FLAT CHARGE
SHALLOW CONE
DEEP CONE
FRAGMENTS OF CAVITY LINING AND ARMOR
ARMOR THICKNESS

33.9

Figure 12-3.—Penetration effectiveness of various shaped charges.

nonelectric blasting cap. A hole located through the lower part of the cap well accepts detonating cord.

After the charge is prepared for firing, the blasting cap or detonating cord is activated to detonate the RDX. The high-explosive force is directed by the copper cone into a narrow jet for penetration of the target with a high order detonation.

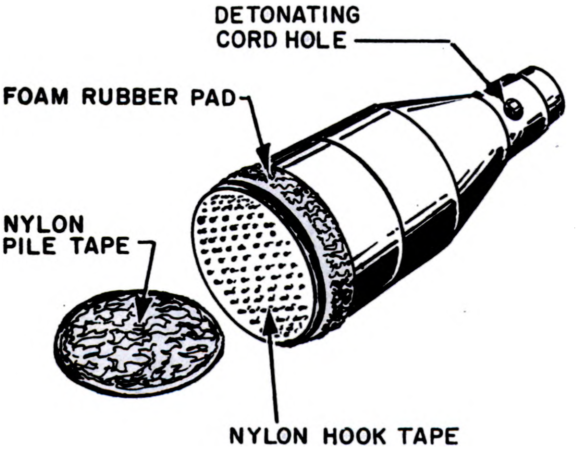


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Figure 12-4.—Mk 45 Mod 0 demolition shaped charge.

M2A3 SHAPED CHARGE.—The M2A3 shaped charge is shown in figure 12-5. Its primary application is against reinforced concrete or armor plate. It blasts a hole into which a more powerful explosive charge can be placed.

The M2A3 shaped charge is larger than the Mk 45 shaped charge just described. It contains about 11.5 pounds of 50-50 pentolite explosive or 9.4 pounds of composition B with 2.1 pounds of 50-50 pentolite booster. The entire charge weighs about 15 pounds.

It comes in an olive-drab, moisture resistant, molded, fiber container. The charge has a high-density glass cone. A threaded activator or cap well permits priming with a blasting cap or any standard firing device. Correct stand-off distance is obtained when the stand-off sleeve (with scalloped base) is resting on the target.

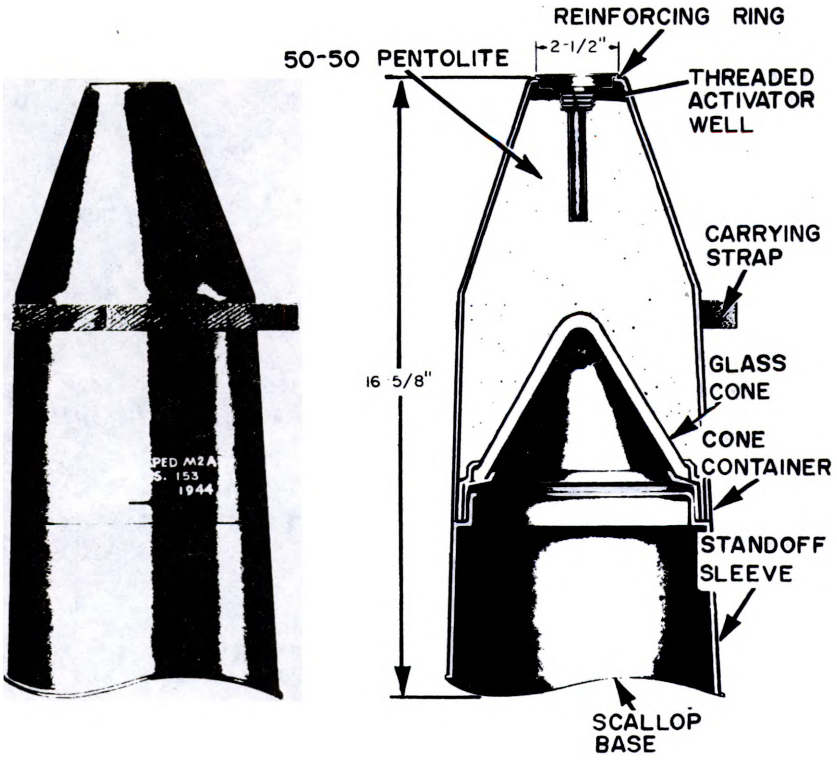

Figure 12-5.—M2A3 demolition shaped charge.

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The M2A3 shaped charge will penetrate armor plate to a depth of 12 inches. Because of the high-density glass liner in the cone, this charge produces a hole of greater volume, but less depth than a steel-lined charge. However, an advantage is that a second demolition charge can immediately be used after the first. The material of the cone forms a glass lining in the hole. This can be shattered and removed, leaving the hole cool enough for the second charge.

DEMOLITION CHARGE INITIATORS

There is a wide range of igniters, detonators, blasting caps, fuses, and firing devices used to initiate a demolition charge. The variety of initiators available permits a good degree of flexibility in the design of demolition charges. This means demolition operations can be carried out efficiently and safely.

Blasting Caps

Blasting caps are designed to be inserted into the activator or cap wells of a charge. Special blasting caps differ from ordinary blasting caps. Special caps are used to detonate less sensitive explosives like TNT, ammonium nitrate, or military dynamite.

All blasting caps are extremely sensitive and may explode unless handled correctly and carefully. They must be protected from shock, extreme heat, and tampering. Blasting caps must never be stored with other explosives.

SPECIAL ELECTRIC DELAY BLASTING CAPS, NUMBERS 1-15.—An external and internal view of this type blasting cap is seen in figure 12-6. These caps are used to initiate high explosives when a source of electricity is available. The power may come from a blasting machine or a battery. These caps are also waterproof.

The cap consists of a thin aluminium tube with four charges. The base charge is either PETN or RDX. The primer charge is lead azide. The time delay charge can be of various lengths which will burn for a prescribed time. The time difference between each number (Nos. 1 through 15) averages about 1 second.

The cap has two plastic-covered copper lead (or connecting) wires about 12 feet long. A bridge wire is attached to the lead wire terminals and sealed into the cap. The lead wires are different in color. Their bare ends are tinned to prevent fraying. To protect against stray currents, the bare ends of the lead wires are shorted together by a shunting device. This device is easily removable and varies in shape to identify the manufacturer. Twisting the bare ends together has the same effect.

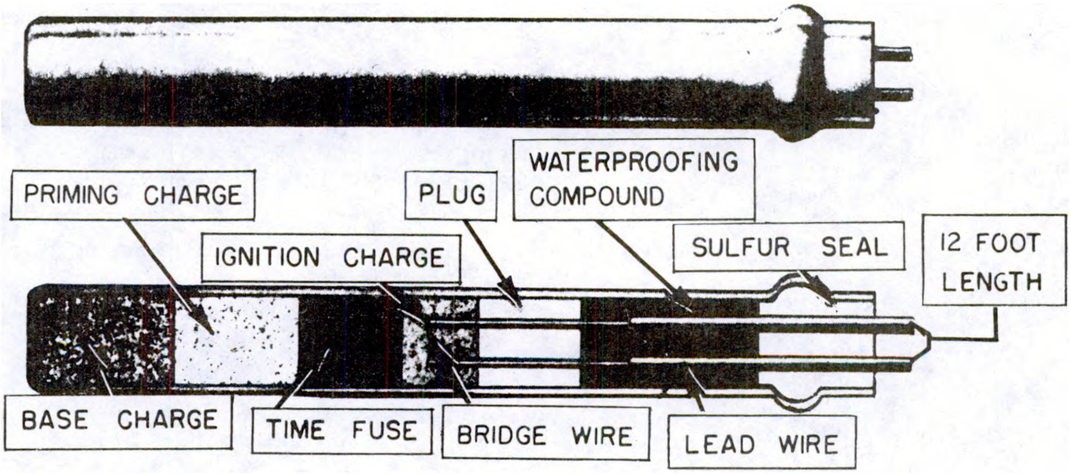

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Figure 12-6.—Special electric blasting caps; Nos. 1-15 delay.

After the blasting cap has been prepared for firing, its electrical power source is activated. A minimum of 1/2 ampere of current is required through the lead wires. The bridge wire becomes heated and ignites the ignition charge. The ignition charge ignites the time delay charge. The flame from the time delay charge is transferred to the priming charge. The priming charge then detonates the base charge.

M6 ELECTRIC BLASTING CAP.—The M6 cap is very similar to the Nos. 1 through 15 delay caps just described. Figure 12-7 shows the two basic models of the M6 cap.

The M6 cap does not have a time delay charge. The compositions of the ignition, intermediate, and base charges are shown in the figure. The 12-foot lead wires extend through a rubber plug assembly or a cast sulphur and smaller rubber plug assembly.

The M6 cap is unique because its electrical characteristics are closely controlled. This permits M6 caps from different manufacturers to be mixed in a firing circuit without causing misfires.

SPECIAL NONELECTRIC BLASTING CAP.—A typical special nonelectric blasting cap is shown in figure 12-8. It is used to initiate high explosives in the same manner as special electric blasting caps. However, nonelectric caps are not very suitable for wet or underwater operations.

The cap consists of a thin aluminum tube with a base charge of PETN or RDX. A priming charge and an ignition (flash) charge containing lead azide are also in the tube. The three charges (base, priming, and ignition) are assembled in layers and only partially fill the tube. The upper end of the tube is empty (hollow) and accepts a time blasting fuse. When a fuse is inserted into the tube, the upper end is crimped to secure the fuse and cap together.

Time Blasting Fuse and Fuse Igniter

A time blasting fuse (correctly spelled with an "s" is used to transmit a flame from an igniter to a nonelectric blasting cap or some other explosive charge. It provides a burning time delay before explosive initiation. This time delay gives personnel adequare time to clear the danger area.

A typical time blasting fuse is shown in figure 12-9. It is a flexible cord about 1/4 inch in diameter. The fuse consists of a black powder

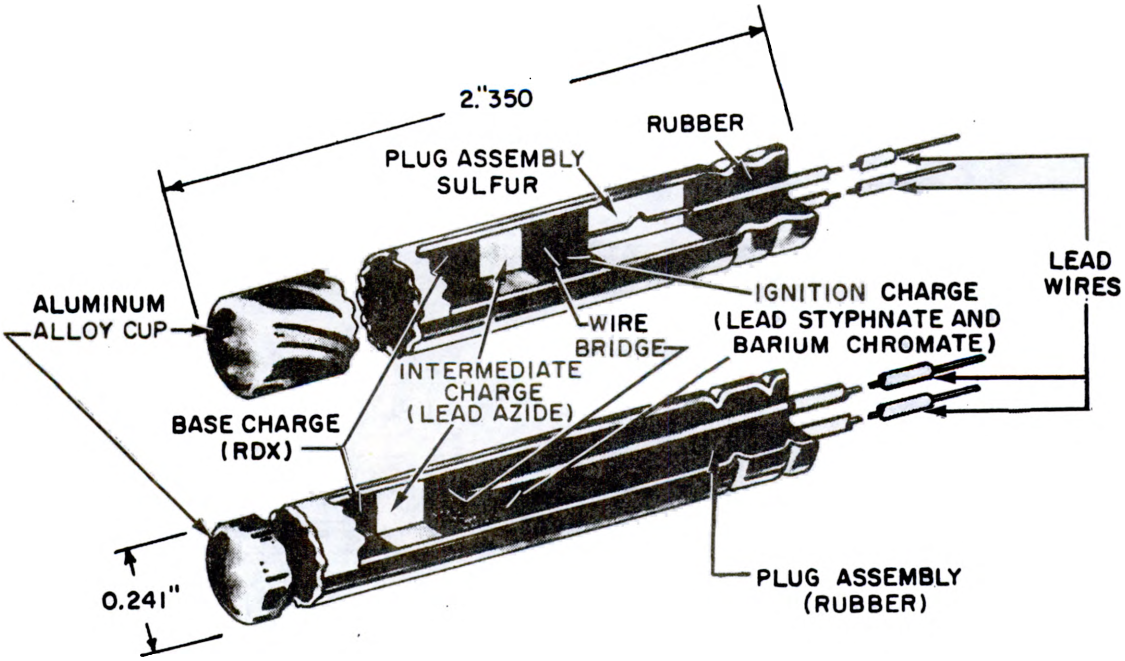

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Figure 12-7.—M6 special electric blasting cap.

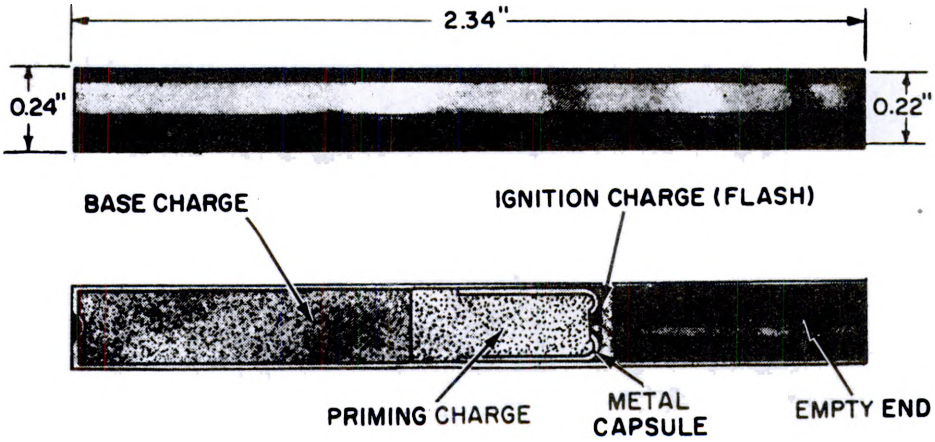

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Figure 12-8.—Special nonelectric blasting cap.

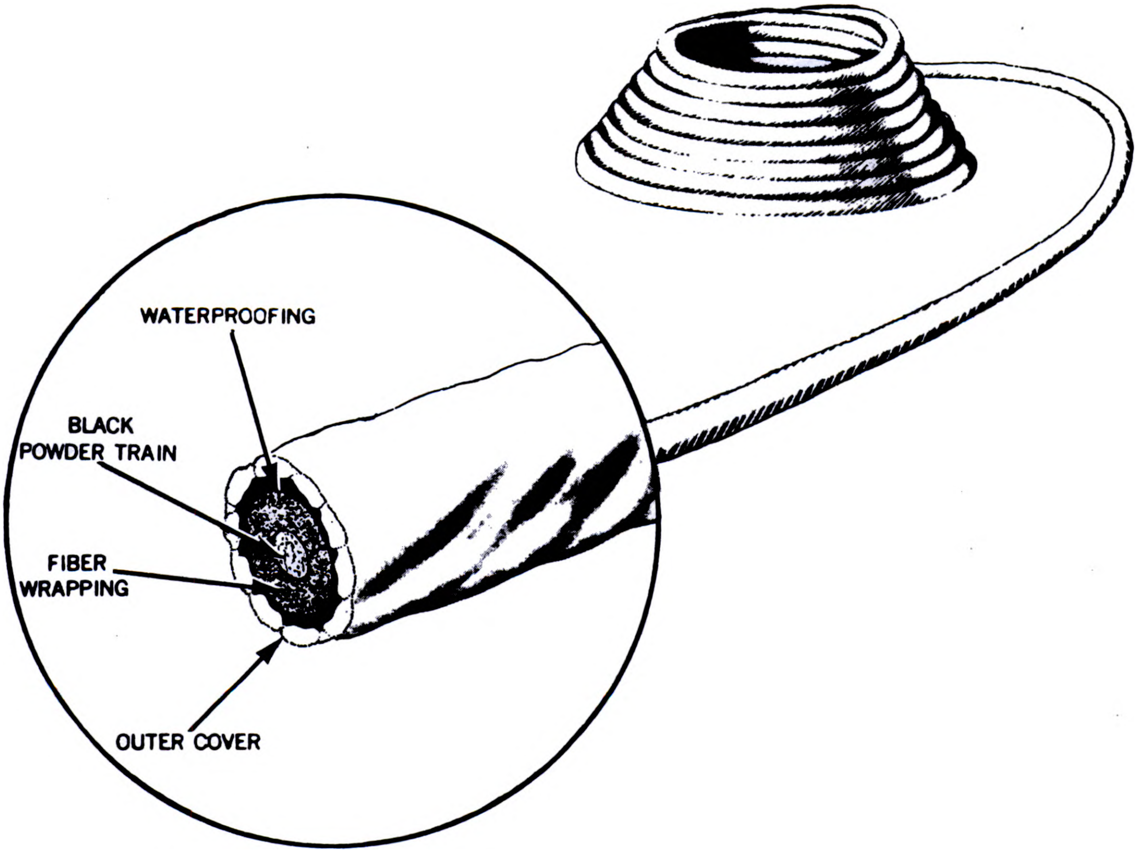

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Figure 12-9.—Time blasting fuse.

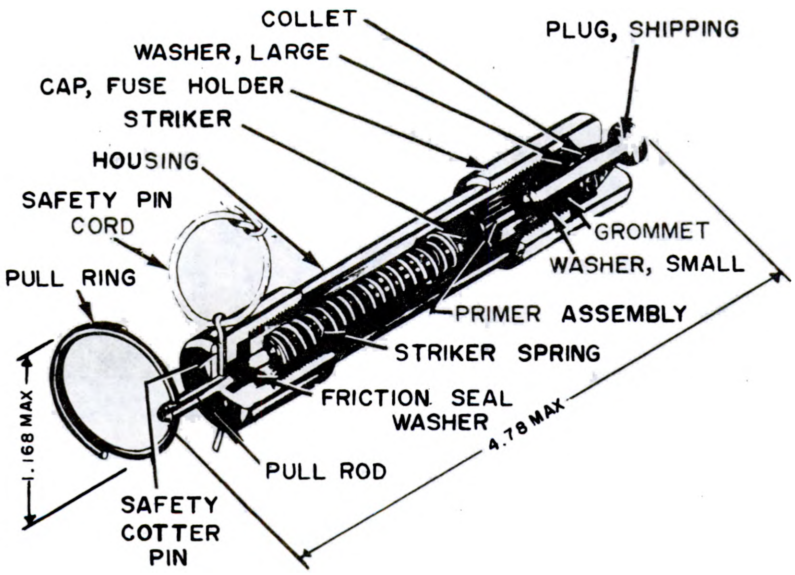

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Figure 12-10.—M60/T2 time blasting fuse igniter.

core encased in a fiber wrapping. The wrapping is covered with a waterproofing material.

The outer surface of the fuse is composed of spirally wound paper and cotton fibers. They are coated to a smooth finish by double-dipping in orange-colored wax. Time blasting fuses issued by NAVSEASYSCOM burn at different rates. The average burn rate is between 30 and 45 seconds per foot. The fuse may be ignited by an ordinary match or fuse igniter. (A fuse igniter is more reliable and preferred.) The black powder burns at a uniform rate and transmits a flame to the initiator or blasting cap.

Figure 12-10 shows a typical time blasting fuse igniter. This model is designated M60/T2 and can be used in either dry, or wet (underwater) locations. The igniter consists of a plastic cylindrical assembly. The major components of the fuse igniter are the firing, fuse holder, and primer-base assemblies.

In use, the shipping plug is replaced with a time blasting fuse. The safety cotter pin is removed and the pull ring is pulled outward. This brings the pull rod and striker (firing pin) back against spring pressure. At some point in this pulling action, the striker assembly disengages from the pull rod. The compressed spring then drives the striker forward to hit the primer. (The primer is a percussion cap-type primer.) The primer activates and ignites the time blasting fuse.

Figure 12-11 shows a typical percussion cap primer. When struck by a firing pin (striker), it emits a small but intense flame. The primer

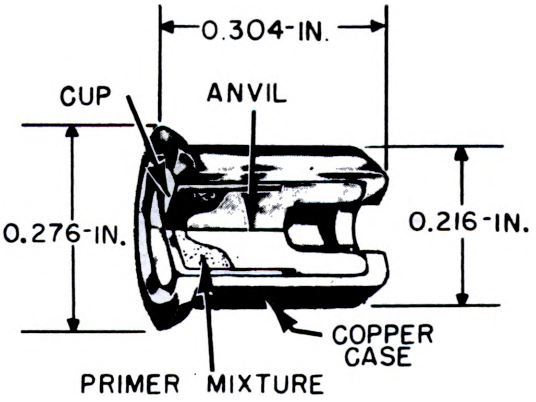

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Figure 12-11.—Percussion cap primer.

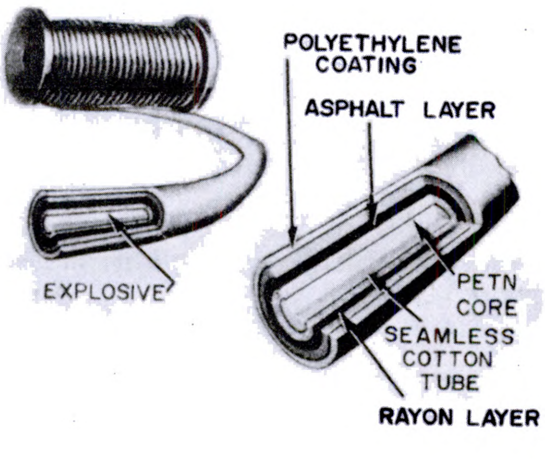

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Figure 12-12.—Detonating cord PETN (Primacord).

contains an inverted cup within a copper case. An impact-sensitive initiating charge and an anvil are inside the cup. When hit by a firing pin, the impact ignites the primer's mixture. Percussion cap primers are normally installed in the firing devices when they are issued.

Detonating Cord

A detonating cord is a very unique and versatile demolition material. For example, it can be used as an initiator, a booster charge, or alone as an explosive (main) charge. Figure 12-12 shows a typical detonating cord. This particular example is called PETN detonating cord or Primacord.

PETN detonating cord is particularly useful for initiating charges in wet boreholes or underwater. The explosive PETN core is contained in a textile tube coated with a thin layer of asphalt. The outer textile covering is finished with a wax gum composition or plastic coating.

This type of detonating cord (Primacord) weighs about 14 pounds per 1,000 feet and has a tensile strength of around 80 pounds. Other types of detonating cord are slightly heavier and have a greater tensile strength. Generally, most detonating cords transmit a detonating wave from one point to another at a fairly equal rate. This rate is about 26,000 feet per second! Can you convert this to miles per hour? Basically, we'll say it is quicker than a heart beat! This is an excellent reason of why NOT to mistake detonating cord for time blasting fuse cord.

Detonating cord may be used for detonating single or multiple demolition charges. It explodes throughout its entire length with sufficient force to simultaneously detonate any arrangement of properly connected charges. Detonating cord may be initiated by a detonating cord initiator, electric blasting cap, or a nonelectric blasting cap.

DEMOLITION ACCESSORIES

There are quite a few inert and explosive accessories used in demolition operations. We will briefly discuss a few of the "accessories" you might encounter.

Priming Adapters

Priming adapters are used to secure an electric or nonelectric blasting cap in the threaded activator or cap wells of standard charges. Figure 12-13

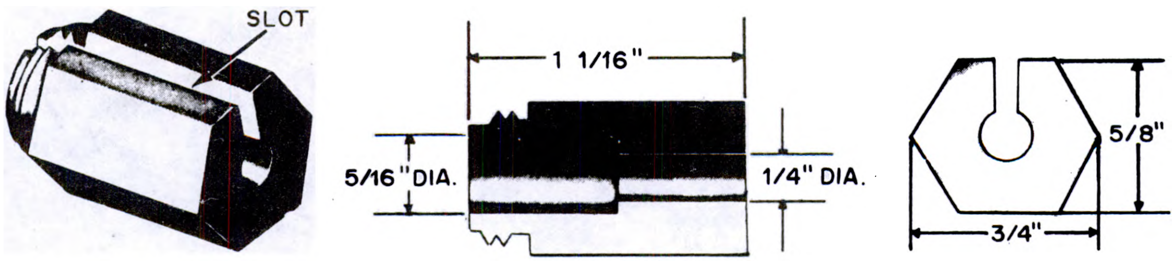

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Figure 12-13.—Priming adapter.

shows a typical adapter. It is made of plastic and screws into the cap well. The bore in the threaded end is large enough to receive a blasting cap. A smaller bore in the other end is large enough to receive a time blasting fuse or detonating cord. A slot allows the lead wires of a blasting cap to be inserted into the adapter. See figure 12-14.

M2 Blasting Cap Crimper

This special demolition tool is shown in figure 12-15. It is used to crimp the open end of a nonelectric blasting cap to a time blasting fuse or a detonating cord. The crimper is made of a nonsparking metal and may be used as a screwdriver, punch, or cutter. The stop provides a definite limit to the amount of pressure that can be exerted in crimping.

Blasting Machines

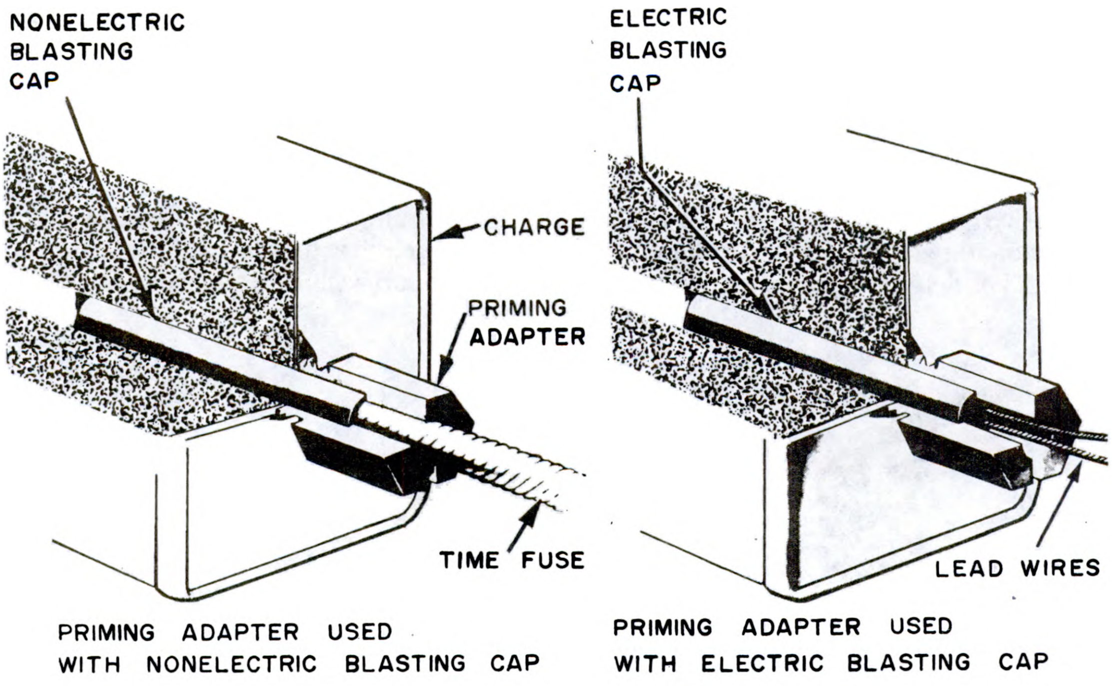
There are a variety of blasting machines available. They are hand-operated devices used to generate the electric current that initiates electric blasting caps. Figure 12-16 shows a 10-cap blasting machine. (Other models can handle 30 and 50 caps.)

The 10-cap blasting machine is a magneto-type electric generator housed in a waterproof case. It can initiate 10 special electric blasting caps connected in series. The firing cable's wires are attached to the two terminals. A quick 90° twist (clockwise) with the detachable handle generates the power.

Galvanometer

The galvanometer is a circuit tester ESPECIALLY designed for demolition work. It tests firing circuits and electric blasting caps for electrical continuity.

The galvanometer (figure 12-17) is normally protected inside a leather carrying case. The galvanometer consists of a small silver chloride battery cell and a permanent magnet with a moving coil mounted between its poles.


NONELECTRIC BLASTING CAP
CHARGE
PRIMING ADAPTER
TIME FUSE
PRIMING ADAPTER USED WITH NONELECTRIC BLASTING CAP
ELECTRIC BLASTING CAP
LEAD WIRES
PRIMING ADAPTER USED WITH ELECTRIC BLASTING CAP

83.544

Figure 12-14.—Installation of a priming adapter.

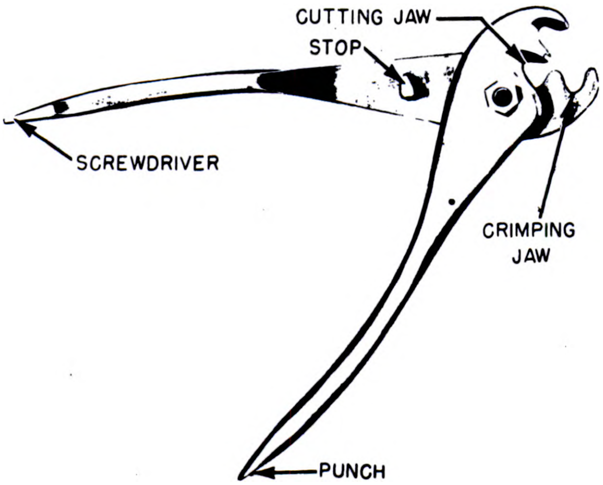


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Figure 12-15.—M2 blasting cap crimper.

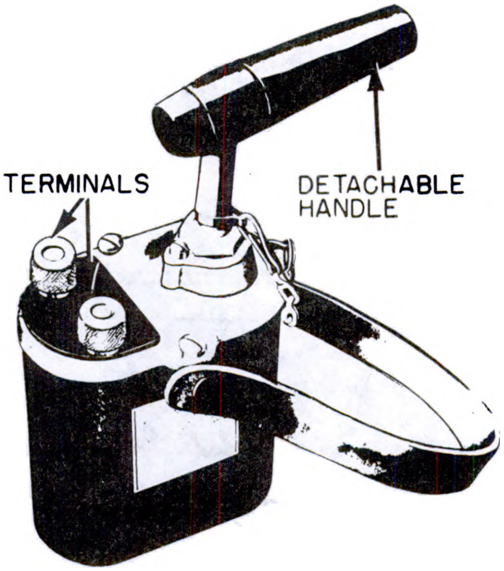

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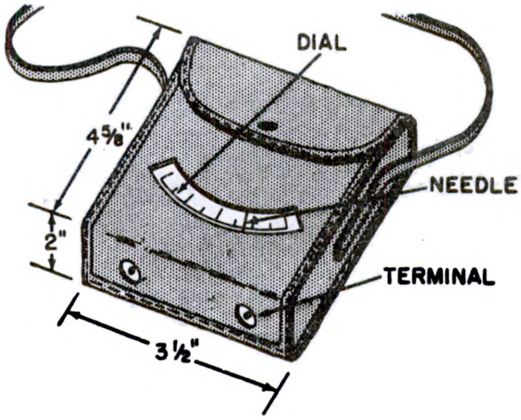
Figure 12-16.—Ten cap blasting machine.

When the galvanometer is connected to a closed circuit, the flow of current from the battery causes the indicator needle to move across the scale. The amount of deflection depends upon the amount of resistance in the circuit.



84.3

Figure 12-17.—Galvanometer circuit tester.

A BASIC DEMOLITION SETUP

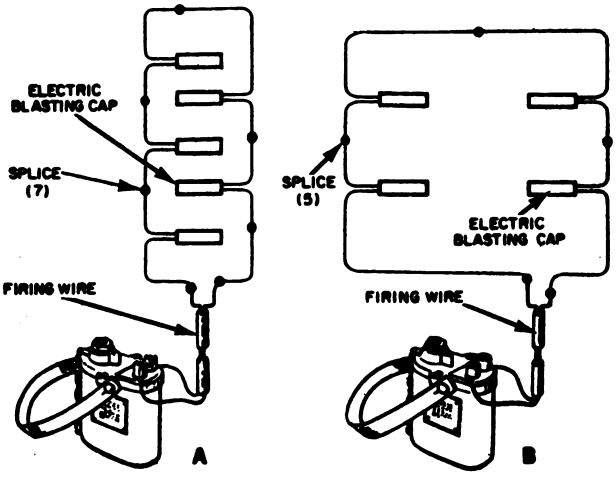
As we emphasized at the beginning of the demolition area in this chapter, you are NOT a demolition expert. Only hands-on, extensive, and highly supervised training will qualify you to use demolition materials. However, as a Gunner's Mate, you have two basic responsibilities:

1. Know what demolition materials are aboard your ship and how to properly maintain them.
2. Have a general idea of basic demolition techniques if called upon to use these materials.

If you must set demolition charges, you will naturally be guided by higher authority. When assigned the task, first think it through very carefully. Consider what is being demolished, how many charges will be needed, and where to place them for best results.

The text will describe a very basic demolition setup. The major equipment used in our example includes:

1. Mk 2 55-pound demolition charges.
2. Special electric blasting caps.
3. Blasting machine.
4. Galvanometer circuit tester.
5. Various accessories; priming, adapter, firing wire, insulation tape, etc.



83.206

Figure 12-18.—View A—leapfrog series circuit; View B—common series circuit.

Step 1.

Usually you will set off several charges at once. To do this, place the charges and make up the firing circuit (blasting machine and all charges) in series. Figure 12-18 illustrates two methods of laying out a series circuit.

Step 2.

Make sure your caps are all from the same manufacturer. Except for the M6 described earlier, caps of different makes should NEVER be used together in one circuit. Be sure not to use more caps than your blasting machine is designed to handle. It is actually better to use fewer. When you remove the caps from their shipping box, do not try to pry them loose with a sharp instrument. Use your fingers and slide them out carefully. Examine each one. Reject any that show signs of moisture or corrosion.

Step 3.

Carefully straighten the 12-foot coils of lead wires on the caps. Do not put any tension on them as they may be pulled from the cap.

Place the caps behind a suitable barrier or in a heavy gage bucket. Separate the lead wires and test each cap individually with a galvanometer. Do this continuity test as far away from the barrier or bucket as the lead wires will allow. Be sure you use only a galvanometer and NEVER any other test equipment.

After testing each cap, shunt the lead wires together again. Continue the individual testing until all the caps to be used are satisfactory. (Now take a deep breath!)

Step 4.

Test both cable connectors of the firing wire BEFORE they are connected to anything. Make sure their ends are not twisted or shorted together. Touch them to the galvanometer terminals. You should not get a steady indication from the galvanometer needle. (It is okay if it momentarily jumps and then returns to zero.)

If you do get a steady needle deflection, this indicates a short between the cables. This can be caused by defective insulation. If the trouble cannot be corrected, test and use another cable.

Step 5.

Next, splice the blasting cap lead wires to the firing wire cables to form the series circuit. There are correct and incorrect ways to splice wires. Figure 12-19 shows one approved method. The

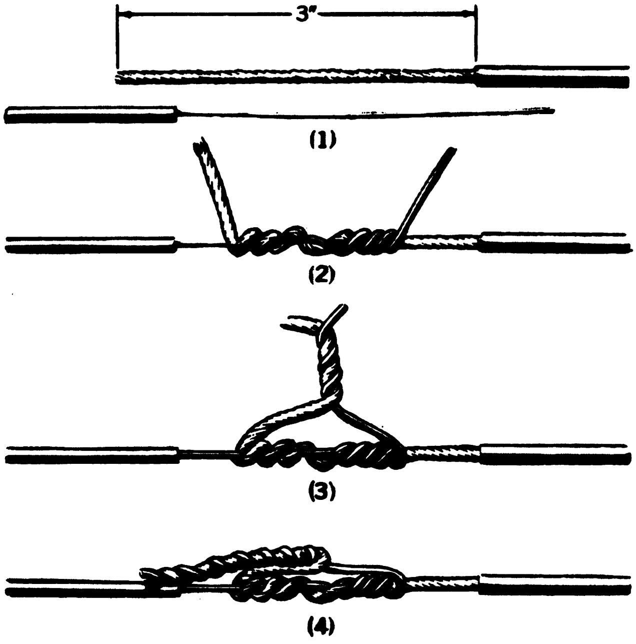
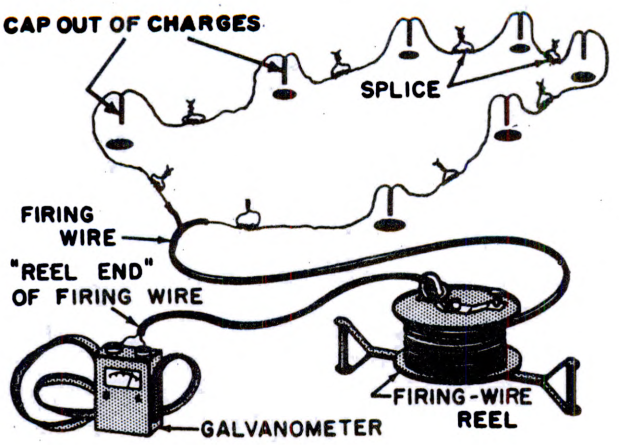


Figure 12-19.—Method of splicing one pair of wires.



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Figuer 12-20.—Testing the firing circuit.

insulation is stripped back about 3 inches and the wires are twisted into a pigtail. If there is a possibility your splice may touch a ground, metal, or another conductor, wrap it with electrical insulation tape.

Step 6.

After the caps are connected, test the entire circuit. Do NOT connect the blasting machine yet. Test the circuit with the galvanometer as shown in figure 12-20.

This time you should get a definite, steady needle deflection. If you do not, check your workmanship. Test each splice and cap individually if necessary to isolate the break.

Note in figure 12-20 that the blasting caps are NOT installed in their charges at this time.

Step 7.

If the circuit has tested satisfactory up to this point, the next step is to prime the charges. Open the top of the Mk 2 demolition charge shipping boxes. The charges need not be removed to be used.

Break the paper seal protecting the activator or cap well in the booster (a 1-lb TNT block). Make sure there is no dirt inside the well. Do not use the blasting cap to break the paper seal.

Step 8.

Next, connect the priming adapters to the blasting caps. Slip the lead wires of a cap through the slot in an adapter. The threaded end of the adapter should be pointing toward the cap when you do this. See figure 12-21.

If the lead wires do not easily slide through the slot, do not force them by pulling on the cap. Grasp the wires about 6 inches back from the cap and slide the adapter along the wires away from the cap. Tilt the adapter as you do this to make the entry of the wires easier.

Step 9.

Insert the blasting cap into the activator well of the booster. Do this gently. Hold the adapter away from the cap until the cap is all the way in the well.

Now ease the adapter down the lead wires until it reaches the threads of the well. Screw it in gently but firmly as far as it will go.

With the cap and adapter in place, give the lead wires a little slack and secure them. The Mk 2 demolition charge has cable or wire anchors under the bolts in the booster cover. You can secure the cable to them or wrap the wires around the charge. The idea is to prevent any strain on the lead wires as they enter the cap. (Oh, you can breathe again.)

Step 10.

If time permits, it is a good idea to repeat the circuit test again. Even if you tested it satisfactory before priming the main charges, there is always a chance something came loose, etc. The procedure is the same as seen in figure 12-20,

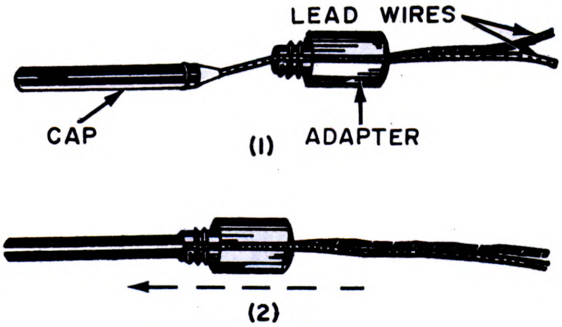

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Figure 12-21.—How to assemble the priming adapter and cap before priming the charge.

except the caps are now in the charges. If you've come this far, don't goof up and use something other than the galvanometer circuit tester.

Step 11.

The last step is to connect the circuit. Make sure EVERYTHING is ready and all personnel have cleared the danger area.

Connect the circuit cables to the blasting machine as shown in figure 12-18. Most blasting machines have removable handles. Remove the handle while you are making the connections. Do not install the handle until you are ready to detonate.

To operate the blasting machine, as seen in figure 12-16, twist the handle smartly. Be sure to turn it through its full range to develop maximum current.

Step 12 (Maybe).

If a misfire occurs, try firing once again. If the second attempt still fails, remove the blasting machine handle. Put it in your pocket to make sure no one else operates the machine inadvertently. Disconnect the machine from the circuit and twist the firing wires together.

After the last attempted firing, wait a minimum of 30 minutes before approaching the demolition area to investigate the trouble. Stay behind a safety barrier and ensure other personnel don't "wander" into the area accidently.

PYROTECHNICS

Pyrotechnics is a Greek word for fireworks. Although the Navy does not use pyrotechnic devices for celebration purposes (e.g. the 4th of July), the principle is the same. Most of our pyrotechnic devices contain combustible substances or chemicals that can be ignited. When activated, they produce a flame, flash, smoke, or sound display. In many cases, a combination of these effects is produced. These displays are used for illumination, signaling, or marking purposes.

In the following sections, we will first study some general information concerning pyrotechnics. Then we'll examine a few of the more common pyrotechnic devices that you may encounter. As Gunner's Mates, our primary responsibilities toward pyrotechnic devices are, again, the safe stowage and handling of these materials.

The main reference source on this subject is NAVSEA's publication covering pyrotechnic, screening, and marking devices. OP 4 and OP 5 provide additional information on pyrotechnic materials. Consult these publications.

PYROTECHNICS—GENERAL INFORMATION

Pyrotechnic devices must be clearly marked for easy identification. The information to be displayed includes the nomenclature and mark and model of the device, the manufacturer's symbol (or name), and the date of manufacture. Also look for a national stock number (supply) and an inspection acceptance stamp.

Color coding is required for pyrotechnic devices. The different colors or combination of colors identify the use and relative hazards of the explosive material contained within the device. Most pyrotechnic devices have an all-white exterior or a white band around them. Pyrotechnics that have a significant amount of low explosives are additionally marked with a narrow brown band. This band is located on the white surface or immediately next to the white band. A light green band indicates a smoke-screening device.

Exterior paint on screening device containers, in particular, must be periodically inspected for chipping or other signs of deterioration. The exterior paint can be retouched or repainted as necessary to maintain the integrity of the stenciling.

Pyrotechnic devices generally are initiated by means of an "ignition train." This train typically consists of an igniter, a delay element, and a starting mix. There are two types of ignition trains—indirect and direct. If they are indirect-firing or out-of-line, one of their elements is displaced when the device is in a safe position. This makes complete operation of the device impossible. Some external force, such as centrifugal force or a change in hydrostatic pressure, is used to bring the displaced element into line. Certain ignition trains do not have a shunting or ignition-interrupting feature. They are called direct-firing or inline ignition trains.

All pyrotechnic and smoke-screening devices are designed to withstand normal handling. They should, however, be handled as little as possible. This reduces the chances of damage which might cause accidental ignition or leakage. Many devices contain materials of a dangerous nature. They are, therefore, designed with safety features which must be maintained in good operating condition. Dents, deformations, or cracks in the outer body may interfere with the proper functioning of the safety features. These problems may also cause accidental ignition during handling or stowage. It is imperative that extreme care by taken to prevent any damage to all pyrotechnic device containers.

The proper functioning of pyrotechnic devices can frequently be affected by moisture. Some compositions may become more sensitive and dangerous when exposed to moisture. Others tend to become difficult to ignite and less dependable in operation. Many devices are sealed against moisture penetration. Care must be exercised to prevent damage that would interfere with these seals. Some screening devices produce their smoke by reaction of their chemical contents with moisture in the air. All container seals must be kept intact.

Pyrotechnic devices may be adversely affected by excessively high or variable temperatures. Storage should be in dry, well-ventilated places. These devices should never be stored where direct rays of the sun could generate excessively high temperatures. Most pyrotechnic devices have been designed to withstand temperatures from −65 °F to 160 °F. However, it is recommended that every reasonable effort be made to maintain stowage temperatures below 100 °F.

HAND-HELD PYROTECHNIC DEVICES

Hand-held pyrotechnic devices are primarily used as signaling devices. They are held during their entire operating time. Quite often these devices are part of the ship's lifejacket, liferaft, or small boat gear. The ship's Boatswain's Mates will usually perform the routine maintenance and inspections of these devices. But, stowage and handling is the job of the Gunner's Mate.

We will discuss three types of hand-held pyrotechnic devices. They are:

1. Mk 1 Navy light
2. Mk 13 marine smoke and illumination signal
3. Mk 79 illumination signal kit

Navy Light

The Mk 1 Navy light is designed to provide a bright light for recognition and signaling purposes. The light can be seen up to 3 miles in clear weather. The Mk 1 Mod 0 Navy Light produces a red signal and burns for 135 seconds. The Mk 1 Mod 1 Navy Light produces a blue signal and burns for only 75 seconds. The two devices are similar in appearance and construction. See figure 12-22.

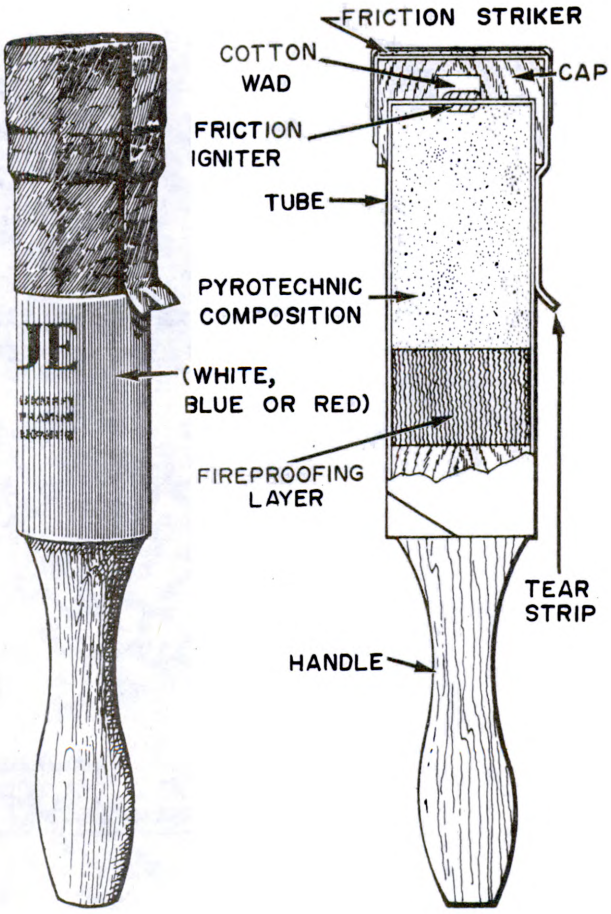

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Figure 12-22.—Mk 1 Navy light.

The Navy light consists of a paper tube containing the pyrotechnic composition. It is fitted with a wooden handle at one end. The opposite end is closed by a cover or cap. The cap has an exterior coating of the same abrasive material found on the side of a safety-match box. Beneath the cover is a small cotton wad. It protects the friction igniter that is impregnated in a cloth substance covering the pyrotechnic composition. The friction igniter is the same material similar to that used in the head of a safety match.

The signal is ignited by scraping the inverted cover across the friction igniter. To do this, the cap must first be removed by pulling the tear strip. The device should be pointed upward and away from the body while being ignited.

The Navy light is particularly subject to deterioration in the presence of moisture. It should be kept in its waterproof container until ready for use. If there is encrustation on the signal body or if a vinegarlike order is detected, the device must be disposed of immediately. Put it in a weighted sack and dump the device overboard when authorized.

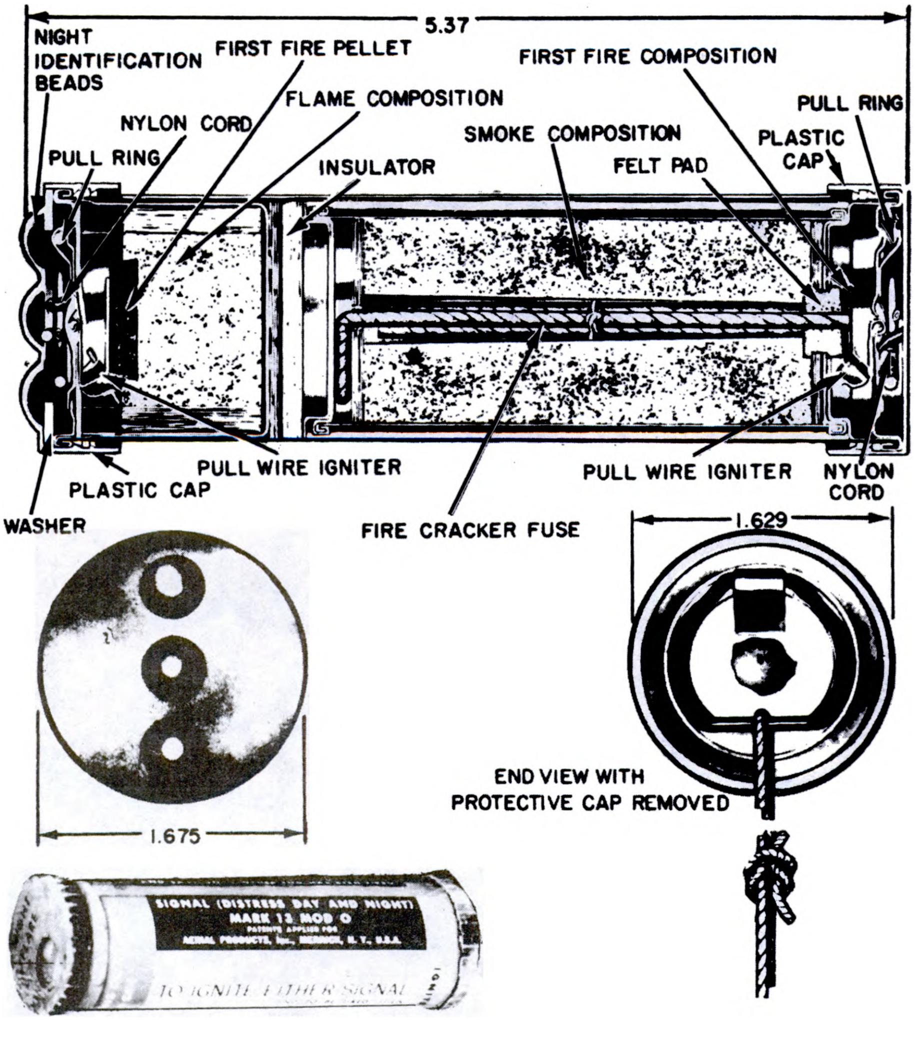

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Figure 12-23.—Mk 13 marine smoke and illumination signal.

Marine Smoke and Illumination Signal

The Mk 13 marine smoke and illumination signal can be used for both day and night signaling. It emits orange smoke for day use and a red flame for night use. Burning time for each display is about 20 seconds. Its small size and weight (about 6.5 ounces) makes it ideal for lifejacket, flight suit, and liferaft application. See figure 12-23.

This signal consists of a metal cylinder 5 inches long and 1.5 inches in diameter. Each end of the cylinder is fitted with a protective plastic cap. The cap on the flame (night) end is molded so that there are three prominent protrusions or beads across its face. These beads positively identify this end, by touch, for nighttime use. The face of the cap at the smoke end is smooth. A label is adhered to the outer surface around the whole body of the signal. It further identifies the smoke (day) and flame (night) ends. It also provides precise instructions for use.

Beneath each plastic end cap is a pull ring with a nylon cord or lanyard. A large washer on the cord at the flame end provides additional identification in darkness. The pull ring at each end is attached to a pull strip seal. The seal is attached to a friction wire that extends inward through a pull wire igniter cup. The igniter cup contains the ignition composition.

A sharp, quick pull on the pull ring causes the friction wire to move through the ignition cup. This ignites the flare mixture (night) or the smoke mixture (day) depending on which type of display is desired.

When you use the signal, point it away from your face. Hold it at arm's length and at a 45° angle. After one end has been used, douse it in water to cool the metal. Each end of the tube is separately insulated and waterproofed. Never activate both ends at once.

Illumination Signal Kit

The Mk 79 illumination signal kit is issued primarily to air crew personnel. If you have an air detachment aboard, you may be responsible for stowage. The kit is intended for use as a distress signaling device. It is small and light so that it can easily be carried in pockets of flightsuits or on liferafts.

The components of the kit are shown in figure 12-24. The bandoleer holds seven signals. Each signal contains a red pyrotechnic star. The projector is used to aim and fire one signal at a time. When activated, the signal star is propelled upward to a height of from 250 to 650 feet. The stars will burn for a minimum of 4.5 seconds.

After the firing pin is cocked, the signal is screwed to the projector's body. The projector is held at a slight angle over the head with arm fully extended. The signal is fired when the trigger screw is slipped out of its safety slot. The firing pin, under spring-pressure, strikes the percussion primer in the base of the signal. The primer ignites the first-fire composition of the star to propel it skyward. The flare composition then ignites to produce the red star signal.

PYROTECHNIC SIGNALS AND PISTOLS

These devices may be launched from either surface craft or aircraft. Pyrotechnic signals and pistols are used as distress signaling devices, producing various brightly-colored lights or smoke.

Marine Illumination Signal

The Mk 2 marine illumination signal was formerly called the Very signal cartridge. It is designed to be fired from the Mk 5 pyrotechnic pistol. The Mk 2 signal displays a red, green, or white star which burns for about 6 seconds. It can reach an altitude of about 200 feet when launched.

The signal resembles a 10-gage shotgun shell and weighs about 1.1 ounces (figure 12-25). Each of the three colors of the star display

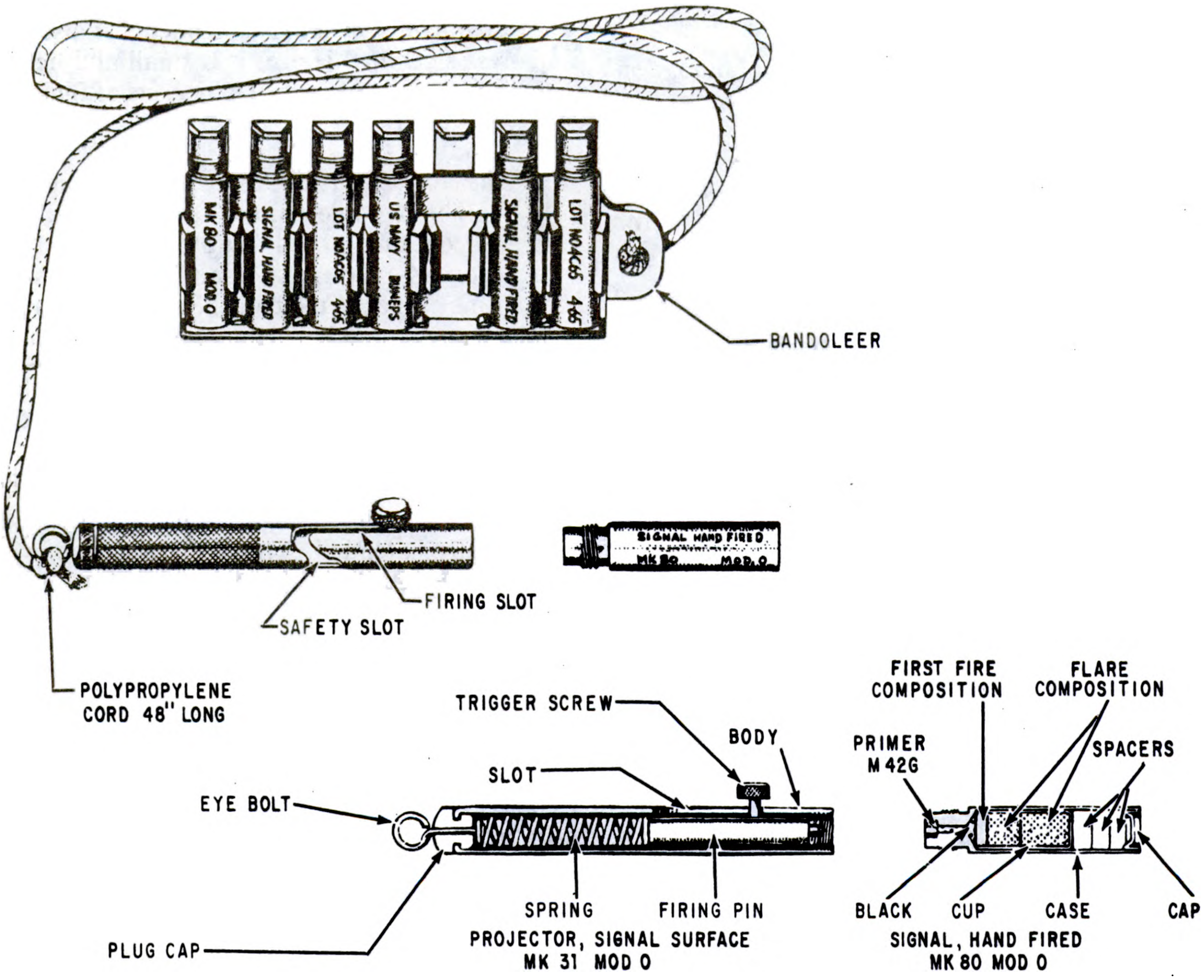

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Figure 12-24.—Mk 79 illumination signal kit.

is indicated by the corresponding color of the signal's paper case. For night time identification, the closing wad of the shell can be felt. The green star is smooth to the touch. The white star has one small, raised projection in its center (a boss). The red star has three parallel or corrugated ridges.

The signal's primer is ignited when struck by the pistol's firing pin. The primer then ignites a propelling charge. The propelling charge shoots the signal skyward and also initiates a quickmatch. The quickmatch is wrapped around the star composition and ignites it.

Never fire a Mk 2 marine illumination signal from a shotgun or projector other than the one authorized.

Mk 5 Pyrotechnic Pistol

The Mk 5 pyrotechnic pistol is seen in figure 12-26. It was designed especially for firing the Mk 2 signal. The pistol consists of a plastic frame with metal mounted parts. Also available are a cartridge belt and holster.

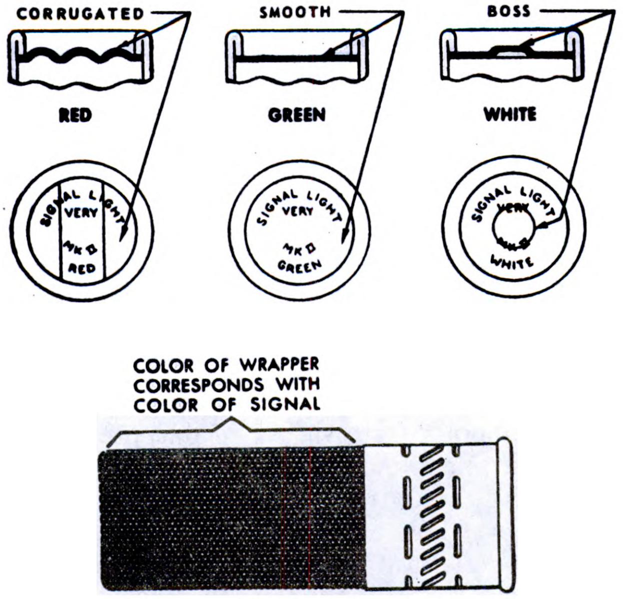
CORRUGATED
SMOOTH
BOSS
RED
GREEN
WHITE
SIGNAL LIGHT VERY MK II RED
SIGNAL LIGHT VERY MK II GREEN
SIGNAL LIGHT VERY MK II WHITE
COLOR OF WRAPPER CORRESPONDS WITH COLOR OF SIGNAL

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Figure 12-25.—Markings on the Mk 2 marine illumination signal.

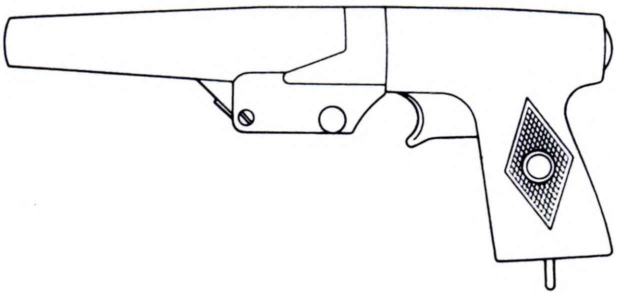

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Figure 12-26.—Mk 5 pyrotechnic pistol.

The breech of the pistol is opened by pushing the latch pin and forcing the muzzle downward. After the signal cartridge is inserted, the breech is closed. This action cocks the pistol. There is no positive safety feature provided. Therefore, do not load the pistol until just before it is to be used. Unfired signal cartridges must not be left in the pistol either.

Aircraft Illumination Signal

The M11 aircraft illumination signal is designed to be fired from the AN-M8 pyrotechnic pistol. It can be launched either from aircraft or surface craft as a distress signal. It displays a single, parachute-suspended red star. The light from the star generates about 20,000 candlepower which is fairly brilliant. The star burns for about 30 seconds and can be seen for 7 to 8 miles in clear weather.

This signal comes in a cylindrical aluminum outer case (figure 12-27). It weighs about 10 ounces, is about 8 inches long, and 1.5 inches in diameter. The outer case contains percussion-type primer in its base. An extraction groove is machined around the base. A metal closing wad is at the forward end of the signal. Raised letters "RP" are embossed in the closing wad to aid in nighttime identification. "RP" stands for red parachute.

After the pistol is loaded and aimed, squeezing the trigger causes the firing pin to strike the primer. This ignites the propelling charge. The

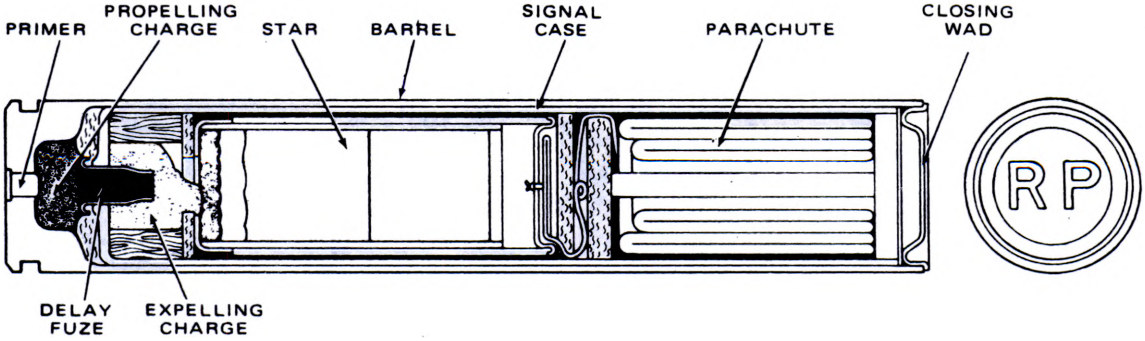

Figure 12-27.—M11 aircraft illumination signal.

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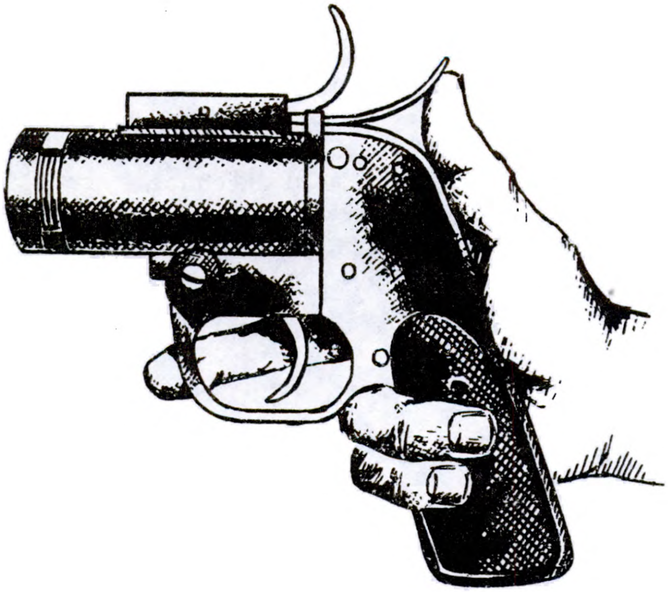
propelling charge ignites the 2.5 second delay fuze and propels the inner (or signal) case from the barrel. The inner case contains the star or pyrotechnic candle and the parachute.

The delay fuze ignites the expelling charge. The expelling charge in turn ignites the candle and expels both the candle and parachute about 150 to 250 feet above the point of launching. The parachute opens to provide a suspended rate of fall at about 6 feet per second.

AN-M8 Pyrotechnic Pistol

The AN-M8 pyrotechnic pistol is designed to fire various cartridge-type distress and identification signals. The M11 aircraft illumination signal just described is only one such example. The Mk 2 marine smoke signal and the AN-M37A2 through AN-M42A2 aircraft illumination (double star) signals are other examples.

The pistol (figure 12-28) has a hinged barrel which is held in place by a breechblock. The plastic grips, backplate, and cover plate are fastened to the aluminum frame. They act as the housing for the firing mechanism.



83.190

Figure 12-28.—AN-M8 pyrotechnic pistol; tripping the breechlock.

Loading is accomplished by raising the breechblock with the thumb and allowing the breech to open. After the cartridge signal is inserted, the breech is closed. Again, there is no positive safety on this pistol. Don't load until ready to fire.

PYROTECHNIC MARKING DEVICES

Pyrotechnic marking devices, commonly called markers, are dropped into the water and emit smoke and/or flame. They establish a reference point for a variety of purposes. They may determine wind direction and velocity. They can mark the location of an emergency night landing by a downed aircraft or a man overboard. They can establish an initial contact point for a continued search for a submarine or locate target areas in ASW operations. Sometimes these markers are called "smoke floats."

The devices can be launched from surface ships, aircraft, or submarines. Markers that use dye as their visual display usually do not contain pyrotechnic materials and, therefore, won't be discussed.

Most smoke/flame markers burn pyrotechnic compositions containing red phosphorus. Red phosphorus is easily ignited by friction. In the process of combustion, some of the red phosphorus is converted into white phosphorus. White phosphorus spontaneously ignites on contact with air.

Special care must be exercised in all handling, stowing, transporting, and other operations involving these devices. Extreme caution must be taken when discarding or retrieving spent phosphorus candles. Stowage areas must be inspected periodically for the presence of gas.

There are quite a few different types of location markers. We will limit our discussion to only two examples. They are:

1. Mk 2 marine location marker.

2. Mk 58 marine location marker.

Mk 2 Marine Location Marker

The Mk 2 marine location marker is shown in figure 12-29. It is intended to be hand-launched from surface or aircraft for nighttime marking purposes at sea. This device was formerly known as a Mk 2 depth charge marker.

It consists of a cylindrical copper can about 7 inches long and 5 inches in diameter. Each end of the can is sealed with a tear strip. A pull ring is attached to each tear strip. The strips cover small holes in the can ends.

The main charge of the marker is calcium carbide. Calcium phosphide is contained within a center tube. When both tear strips are removed and the device is submerged, water reacts with these chemicals. The reaction produces acetylene and phosphine gases. The phosphine spontaneously ignites (usually within 90 seconds) and, in turn, ignites the acetylene as it escapes from the top of the can. This produces a smokeless flame about 9 inches in height which burns for about 45 to 55 minutes. It will automatically re-ignite if it is extinguished by wave action.

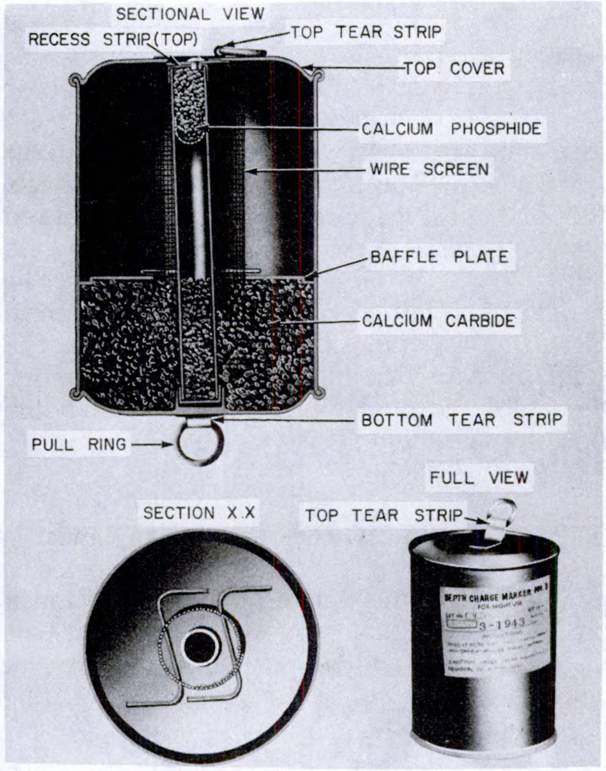


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Figure 12-29.—Mk 2 marine location marker.

The Mk 2 marine location marker must never be lifted or carried by its pull rings. The tear strips must always be protected from damage or accidental removal. If they are damaged or the outer case is punctured, the marker must be kept away from water. Periodic inspections are mandatory. These markers should be stowed separate from other pyrotechnics. The stowage space must be dry and not equipped with a sprinkler system. The phosphine gas produced when the marker comes in contact with water ignites spontaneously and is very toxic.

Mk 58 Marine Location Marker

The Mk 58 marine location marker is shown in figure 12-30. It is designed for day or night use in any condition requiring a long-burning smoke and flame reference point. The marker produces yellow flame and white smoke for about 40 to 60 minutes. They are visible for at least 3 miles during clear weather.

The Mk 58 marker consists of a cylindrical "tin" can about 21.5 inches long and 5 inches in diameter. Each end of the can is hermetically sealed. A twist key is soldered to the bottom of the can. It is used to remove the tear strip on the top of the can. (This is similar to the arrangement used to open certain peanut or candy cans with a vacuum seal.) The outer case is stenciled to show the nomenclature, mark, mod, manufacturer, and date of manufacture information.

The marker contains two phosphorus pyrotechnic candles. They are supported within the device's body by foamed-in-place polyurethane. The first candle is ignited by an electric squib. The squib is fired by a seawater-activated battery in the top of the marker.

When the marker is launched, the pull ring rips off a piece of tape which covers the battery-cavity hole. This exposes the battery to the entrance of

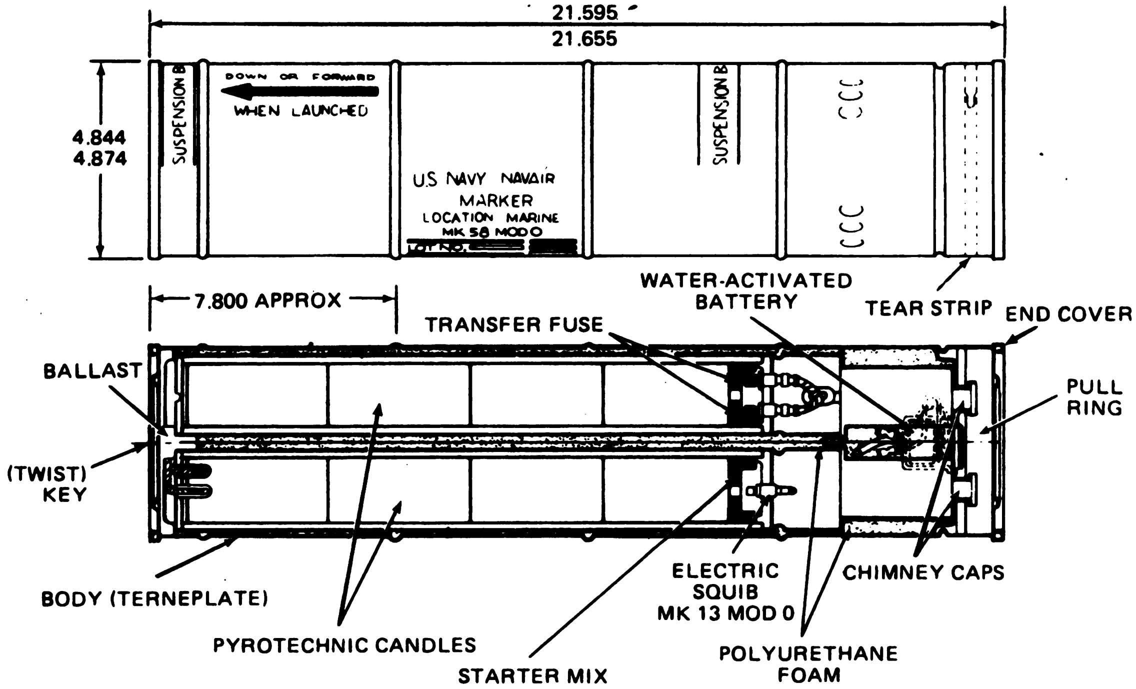

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Figure 12-30.—Mk 58 marine location marker.

sea water which serves as an electrolyte to activate the battery. Current initiates the electric squib to ignite the starter mix of the first candle. The starter mix ignites the candle, which burns from top to bottom.

When the first candle is nearly burned out, its heat ignites the transfer time fuse. This fuse extends from the bottom of the first candle up to the top of the second candle. It carries the heat necessary to ignite the starter mix of the second candle. The second candle is, therefore, automatically ignited. Each candle burns for a minimum of 20 minutes.

Stowage and handling precautions of the Mk 58 marker are similar to those covered with the Mk 2 marker. Since it is water-activated, special care must be taken. If a marker was "made-ready" for use (tear strip and end cover removed), it need not be launched. The cover can be reinstalled and taped. However, the hermetic seal is broken and extra-special stowage and handling care must be observed. This marker can be initially stowed in a sprinkler-protected space. But, once it is "made-ready" it cannot be stowed there.

The phosphorous candles are made of the red phosphorous composition described earlier. The smoke produced is highly caustic to the moist tissues of the nose and throat areas. Do not breathe this smoke; it is very toxic.

EXPLOSIVE ORDNANCE SAFETY

To conclude this chapter, we will briefly touch on the topic of explosive ordnance safety. Our discussion here will be very general. Later, in chapter 14, we will get more specific on this important subject.

Explosive materials are made for one purpose—to explode. A major part of our job as Gunner's Mates is to see that they explode on the enemy or practice target and not around us. Observing the safety precautions regarding explosive materials is only part of our responsibility to safety. We must also ensure that other personnel are aware of and practice these precautions.

Familiarity often leads to carelessness. It happens to everyone. Don't become careless as you handle explosive materials. Concentrate on what you are doing and make safety a habit. Remember, most safety rules have evolved from a past casualty. Follow the rules presented in the OPs and other publications. Two general rules for safety are:

1. If you do not clearly understand the exact meaning of a safety rule or order, ASK what it means. If your supervisors do not know, they will find out through the chain of command.

2. If you find conditions that conflict with a safety rule, REPORT IT to your supervisors. They will evaluate the situation and make any adjustments or corrections if necessary.

REFERENCE SOURCES

The following publications were used to support the information in this chapter.

1. NAVEDTRA 10199-C, *Gunner's Mate M 3 & 2*
2. NAVEDTRA 10185-C, *Gunner's Mate G 3 & 2*
3. NAVEDTRA 10163-D, *Torpedoman's Mate 3 & 2*
4. NAVEDTRA 10784-B, *Principles of Guided Missiles and Nuclear Weapons*
5. NAVSEA OP 4, *Ammunition Afloat*
6. NAVSEA OP 5, *Ammunition Ashore*
7. NAVSEA OP 2212, *Demolition Materials*
8. SW050-AB-MMA-010 (formerly NAVSEA OP 2213), *Pyrotechnic, Screening, and Marking Devices*

CHAPTER 13

SMALL ARMS AND MACHINE GUNS

Strictly defined, the term "small arms" means any firearm with a caliber (cal) of .60 inch or smaller and all shotguns. Since there are no .60-cal weapons in the Navy, all pistols, rifles, shotguns, and machine guns up through .50 cal are small arms. Such weapons are carried aboard ship for certain watchstanders and members of the ship's internal security force.

Small arms intended for match competition (match conditioned) are not covered in this text. They are repairable only at the depot level, such as the Naval Weapons Support Center, Crane, Indiana.

As a third class GM, you will be concerned with small arms, and your responsibility in that field is twofold. First, you must know how to assemble, disassemble, overhaul, and repair small arms. Second, you must be able to train other personnel in the operation, safe handling, care, and cleaning of small arms.

The majority of small arms are procured from the Army and issued by the Navy to its field activities and the fleet. Maintenance on these small arms is performed following the applicable maintenance requirement cards (MRCs). All other information (operation, troubleshooting, parts lists, etc.) is normally found in Army technical manuals (TMs) and field manuals (FMs). The TM lists the spare parts, special tools, and organizational maintenance procedures for a weapon. The FM is the operator's manual. It is intended for personnel in the field who must keep the weapon firing.

TERMINOLOGY

Before we begin the study of the individual weapons, let us examine some of the quirks in small arms nomenclature (names of the parts). Generally, terminology pertaining to the weapons themselves is fairly standard because the Navy has adopted most of the Army's system of identification. For example, the Army uses the letters M and A instead of the abbreviations Mk (mark) and Mod (modification). This means that "carbine M1A2," in Navy language is "carbine Mk 1 Mod 2."

Much of the confusion surrounding small arms terminology lies in cartridge, or round, designations. For example, what is the difference between .30-30, .30-06, 7.62-mm, and the .308 Winchester cartridges? Normally, the designation includes the caliber. Caliber, as referred to in small arms/weapons, is the diameter of the bore of the barrel. It is measured in inches or millimeters. Needless to say, if caliber refers to the diameter of the bore, it also indicates the diameter of the cartridge. A .30-30 designation indicates that the cartridge has a caliber of .30 inch and contains 30 grains of propellant powder. The .30-06 cartridge, for which the 06 Springfield and M1 rifles (formerly Navy standard issue) are chambered, also has a caliber of .30-inch. The number -06, in this case, indicates that the round was standardized in 1906. The 7.62-mm cartridge is a .30-cal round that is used with the Navy standard issue M14 rifle. The .308 Winchester is a commercial .30-cal round. Thus, all four cartridges are of the same caliber. This does NOT mean they can be fired from the same weapon. The shape of the cartridge case often prevents the interchange.

The diameter of a shotgun's bore is referred to as the gauge of the shotgun. (The terms "gauge" and "gage" are interchangeable. This text uses gauge.) Gauge (with the exception of the .410 shotgun) is not a measurement of inches or millimeters. Instead, it is the number of lead balls of that particular diameter required to make a pound. For example, if you measured the diameter of a 12-gauge shotgun's bore, you would find it to be 0.729 inch. If you were to make a number of lead balls of this diameter and weigh them, you would find that 12 of them make a pound. So the larger the bore of a shotgun, the smaller the gauge number. For example, a 12-gauge shotgun has a larger bore than a 16-gauge shotgun.

Following is a list of small arms-related terminology. It is presented for your convenience. Study it carefully.

ACTION—The "action" of a weapon is a term used to cover all the working parts, regardless of method of operation.

BARREL—The metal tube of small arms weapons through which the projectile travels.

BATTERY—A position of a weapon. When all moving parts are in the normal position and the bolt is locked against the breech, the weapon is said to be "in battery."

BOLT—Normally, the fore and aft moving part that closes and opens the breech; part of the breechblock in larger caliber guns.

BORE—The hole running the length of the barrel.

BREECH—The extreme aft end of the barrel, including the chamber.

CALIBER—The caliber of a rifled firearm is the diameter of the bore, measured from land to land given in hundredths of an inch (.22), thousandths of an inch (.357), or millimeters (7.62).

CARTRIDGE—A complete assembly consisting of all components necessary to fire the weapon once; that is, the projectile, cartridge case, propellant, and primer.

CASE—Container for the powder, primer, and projectile. Sometimes you will see the term "brass" used when referring to case. Many types of ammunition containers are (or were) made of brass material. (That's the stuff you love to shine!) Today, steel is the predominant metal used in manufacturing cases. However, the old term "brass" is still around. Case and brass are words used interchangeably. So are "empty case" and "empty brass."

CHAMBER—The portion of the bore at the rear or breech end of the barrel which holds the round when the weapon is loaded.

CHAMBER PRESSURE—Pressure on the chamber's walls resulting from the expanding gases of a fired cartridge. Chamber pressure is expressed in pounds per square inch (psi).

COOK-OFF—Functioning of a round chambered in a very hot weapon due to the heat of the weapon.

COUNTERRECOIL—The forward movement of the moving parts toward the battery position.

EJECTOR—That part which removes the empty case from the bolt or breechblock after it has been extracted from the chamber. It may be part of either the bolt or the receiver and usually flips the case clear of the weapon to the side or downward.

EXTRACTOR—The extractor is a part of the bolt or breechblock which pulls the fired case from the chamber as the bolt is moved to the rear.

FIRING PIN—The device driven against the primer to fire the round. In small arms not using a hammer, the firing pin is held by the sear when cocked.

GROOVE—The recessed-portion of the rifling (figure 13-1).

HAMMER—A hinged piece, driven by spring pressure after release to directly or indirectly strike the primer of the round. In most weapons which use a hammer, it strikes a firing pin or striker, which in turn fires the round. In many revolvers, the hammer and firing pin are assembled as a unit.

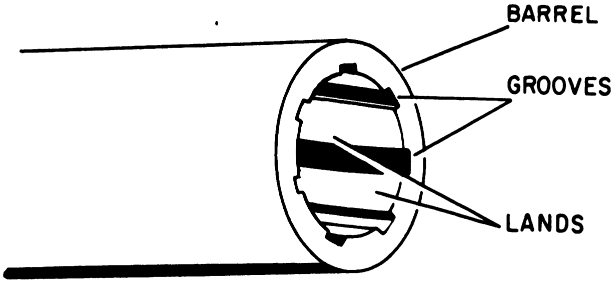

Figure 13-1.—Rifling.

HANGFIRE—A delay in the functioning of a fired round.

LAND—The raised portion of the rifling. (See figure 13-1.)

MAGAZINE—The magazine of a weapon is usually a detachable cartridge container in either a box or drum shape. Most current automatic and semiautomatic small arms use a box-type magazine holding 7 to 30 rounds of ammunition, depending on the weapon.

MAXIMUM EFFECTIVE RANGE—The greatest distance at which a weapon may be expected to fire accurately.

MAXIMUM RANGE—The greatest distance a weapon can fire.

MISFIRE—Failure of a round to fire.

MUZZLE—The extreme forward end of the barrel.

MUZZLE VELOCITY—The speed at which the bullet/projectile travels when it leaves the muzzle. Muzzle velocity is expressed in feet per second (ft/sec).

PRIMER—Small arms igniter.

PROPELLANT—Powder.

RATE OF FIRE—The operating efficiency of a weapon is measured by how many rounds it can fire within a given time. There are three terms to know:

1. Rate of fire (ROF)—The number of rounds fired within (or per) 1 minute; expressed as RPM.

2. Sustained rate of fire (SROF)—The actual rate of fire a weapon can deliver for an indefinite period without seriously overheating.

3. Cycle rate of fire (CROF)—The theoretical number of rounds a weapon can fire in 1 minute. CROF disregards the limits of overheating and magazine capacities.

RECEIVER—The receiver acts as the frame of the weapon. It houses the bulk of the operating mechanism, including the bolt or breechblock. The remaining parts of the weapon (barrel, stock, etc.) are mounted to the receiver. The weapon's serial number is usually engraved on the receiver.

RECOIL—(1) The rearward movement of the weapon; (2) the rearward movements of the moving parts out of the battery position.

RIFLING—The spiral lands and grooves running the length of the bore. The rifling imparts a spin to the projectile as it travels through the bore; the spinning stabilizes it in flight by means of the gyroscopic effect produced. (See figure 13-1.)

ROUND—Same as cartridge.

SAFETY DEVICE—A manually actuated lock that prevents the weapon from firing.

SAFETY FEATURE—A characteristic built into a weapon that prevents inadvertent firing.

SEAR—The part which generally holds the hammer, firing pin, or bolt in a cocked position. The sear is connected to the trigger and engages either the hammer, firing pin, or the bolt, depending on the weapon.

SMOOTHBORE—An unrifled bore, as in shotguns.

STOCK—The portion of small arms weapons which assists the operator in handling and firing the weapon. This part is usually constructed of wood or fiber glass.

PRINCIPLES OF OPERATION

Small arms weapons are mechanisms designed to provide a means of firing ammunition and directing the projectile at a given target. Although they differ in size, caliber, design, and the exact method of operation, all small arms weapons operate on the same basic principles.

The barrel of a weapon is open at the forward end or muzzle. It may be opened or closed at the aft or breech end by means of a removable breechblock or bolt. The bolt is locked in place when the weapon is fired and can be unlocked and opened to reload the weapon.

The breech end of the barrel is enlarged to form a chamber. Into this chamber a metal cartridge, containing a projectile and a measured quantity of propellent, is inserted. Once loaded and the bolt closed and locked in place, the weapon may propel the projectile through the bore by the rapid burning of the propellant charge in the cartridge.

Most modern small arms are fired by percussion. At the base of the cartridge is a small cup which contains a charge of sensitive explosive. This cup and its charge are known as the primer. The primer is so sensitive that it will explode if struck with minimum force. A firing pin or striker, which is driven by a spring, is arranged so that it can strike the primer. The spring providing the driving force may be connected directly to the firing pin or to the hammer.

To cock the weapon, the firing pin or hammer is forced aft, compressing the spring. The weapon is held in the cocked position by the trigger or a small hooked piece known as the sear. When the trigger is squeezed, the cocked firing pin or the hammer is released and forced by its spring tension to strike the primer.

The primer charge in the base of the cartridge ignites the powder propelling charge. Almost instantly the powder burns and is changed into a gas under high pressure. The gas, attempting to expand, exerts pressure in all directions. Pressure is exerted against the side of the barrel, in a forward direction against the base of the projectile, and in a rearward direction against the closed breech of the barrel. The strength of the barrel and the shoulder of the cartridge seated in the chamber prevent the gases from escaping to the sides or through the breech. Thus, the pressure of the gas pushes against the projectile, driving it through the bore. The pressure against the bolt, which is locked to the barrel, causes the weapon to recoil.

CYCLES OF OPERATION

In every weapon, there is a cycle of operation. This cycle is a group of actions that takes place upon the firing of one round and which must occur before the firing of the next round. In the automatic small arms currently used by the Navy, the sequence or manner of accomplishing these actions may vary among weapons of different design. However, these actions are always performed.

The eight steps in the cycle of operation are shown in figure 13-2.

FEEDING (STEP 1)

This action places a round in the receiver just to the rear of the chamber. In its simplest form, it amounts to placing a cartridge manually in the path of the device which will chamber the round. Feeding is often accomplished by a spring-loaded follower in a magazine or clip.

Magazines have a limited capacity which cannot sustain the continuous rate of fire required by machine guns. Therefore, machine-gun ammunition is belted and the rounds are fed to the rear of the chamber by a cam and lever action.

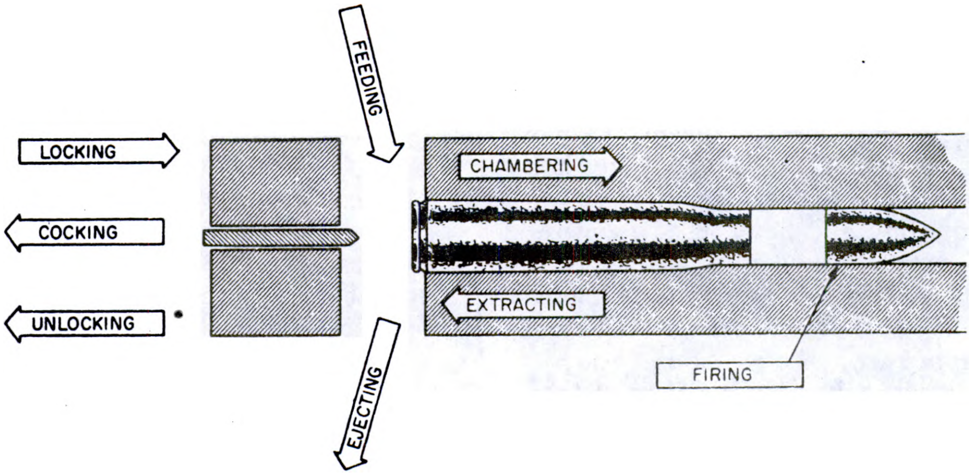

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Figure 13-2.—The eight steps in a cycle of operation.

CHAMBERING (STEP 2)

This action is required to ram a new round into the chamber. Again, in its simplest form, this amounts to placing the round there by hand. In military weapons, chambering takes place as the forward moving bolt strips the round from the feed mechanism and forces it into the chamber. The bolt closes on the cartridge, and the extractor snaps into the extracting groove machined around the base of the cartridge case.

LOCKING (STEP 3)

This action holds the bolt in its forward position for a short period of time (after firing). It prevents the loss of gas pressure until the bolt is unlocked by other forces. For low-powered weapons, it is possible to seal the breech for a short time by merely increasing the weight of the bolt. The bolt starts to move upon firing. However, it will not move far enough to release the gases until their pressure has been satisfactorily reduced. This method is used by submachine guns and other straight blowback-operated small arms such as the .22-cal rimfire autoloading pistols.

FIRING (STEP 4)

Firing is initiated when the trigger is squeezed. When the firing pin strikes the primer of the cartridge, firing occurs. The projectile separates from the powder cartridge and proceeds down the bore.

UNLOCKING (STEP 5)

Unlocking occurs after the round leaves the muzzle. Actions for unlocking are just the reverse of those required for locking. For most rifles, the first movement of the bolt results from a camming action. The bolt is rotated to disengage it from locking lugs. The bolt then moves to the rear.

In the straight blowback bolt there is no camming action. The cartridge is held in the chamber until the gas pressure overcomes the inertia of the heavy bolt. Then the bolt is forced to the rear.

EXTRACTING (STEP 6)

This is the process of pulling the empty case from the chamber. The extractor is normally a small hooked piece of metal encased in the bolt. It snaps over the rim of the cartridge case when the round is chambered. As the bolt moves rearward after firing, the extractor hauls out the empty brass.

EJECTING (STEP 7)

It is not only necessary to pull the cartridge case out of the chamber but also to throw it free of the receiver. This action is called ejection, or ejecting. It is accomplished by placing a small projection on one side of the receiver. As the bolt and empty case move to the rear, the case will strike the projection and be expelled from the weapon. This method is used in the .45-cal pistol. Another method of ejecting uses a spring-loaded ejector in the face of the bolt. In this arrangement the case is flipped from the weapon as soon as its forward end clears the chamber. This method is used in the M14 rifle.

COCKING (STEP 8)

Cocking is the retracting of the firing mechanism (firing pin and/or hammer) against spring pressure. This ensures there will be sufficient energy to fire the cartridge in the next cycle of operation. The firing pin, hammer, or, in some cases, the bolt itself is held in a cocked position by a piece called the sear.

The feeding, chambering, and locking cycles (steps 1 through 3) take place once more. For some weapons, they are accomplished manually. For other weapons, after the first round is fired, they are performed automatically. Squeezing the trigger trips the sear which, in turn, releases the firing mechanism. The firing mechanism moves forward with enough force to discharge the round. The cycle of operation continues.

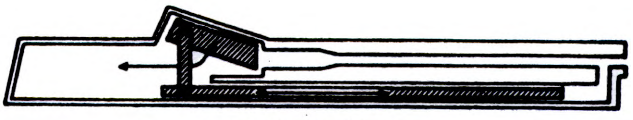
AUTOMATIC AND SEMIAUTOMATIC FIRING SYSTEMS

The manner in which the cycle of operation is performed determines the classification of the weapon. At one time all the steps in a cycle of operation were performed manually. However, performing these operations by hand was time-consuming and slowed the rate of fire. It also required the firer to change position or move the sight off the target after each shot. With the exception of the revolver, all small arms currently in naval service are designed to load (feed) automatically.

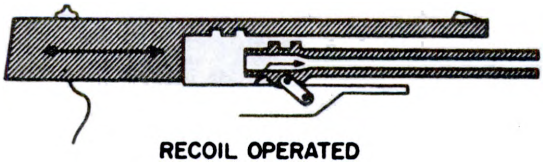
A semiautomatic, self-loading weapon unlocks, extracts, ejects, cocks, reloads, and relocks automatically. However, the trigger must be pulled each time a round is to be fired. A fully automatic weapon keeps firing as long as the trigger is held in the fire position. The automatic weapon is operated by using the forces of the gas pressure generated when a round of ammunition is fired. The forces used do not reduce the effectiveness of the weapon but represent wasted energy that has been put to good use. There are three ways in which the wasted power of the cartridge can be used to operate the weapon: gas pressure, recoil, and blowback. See figure 13-3.

In a gas-operated weapon, a small hole (gas port) is cut into the barrel. When the projectile has passed the hole, some of the compressed gas behind the projectile escapes through the hole. The gas is directed into a cylinder where it drives a piston. The force of the moving piston is used to operate the action.

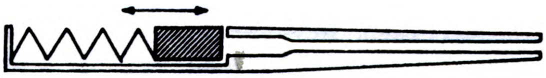
In a recoil-operated weapon, the backward thrust, or recoil, of the barrel and bolt (which are locked together) is used to do the work. After a short distance, the barrel is stopped and the bolt, being unlocked, continues to recoil against spring pressure. It does so until it has moved a sufficient



GAS OPERATED



RECOIL OPERATED



BLOWBACK OPERATED

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Figure 13-3.—Types of operating systems.

distance to the rear to permit the empty case to be ejected. The force of recoil also cocks the weapon and compresses a spring. This returns the bolt to its firing position, loading a new round into the chamber in the process.

In a blowback-operated weapon, the operation principles are similar to a recoil-operated type, but there are important differences. In a blowback-type mechanism, the breechblock and barrel are not locked together and the barrel itself is nonrecoiling. The bolt or breechblock is held in battery only by the weight of the block and the pressure of a recoil spring. In a recoil-operated weapon, the breechblock is never unlocked from the barrel until the projectile is clear of the muzzle and pressure in the barrel is released. The action of a blowback-operated weapon is dependent upon the cartridge case and the breechblock's moving slightly to the rear under gas pressure while the projectile is still in the barrel. Thus, the weight of the breechblock is an important factor in the design of a blowback-operated weapon. This type of operation is highly suitable for relatively low-powered cartridges. However, a military rifle using the standard .30-caliber rifle cartridge in a blowback action would require a breechblock weighing about 27 pounds. It is, thus, apparent that a high-powered weapon cannot be operated with a standard inertia or blowback-type action.

MAINTENANCE

Before we discuss the various small arms and machine guns covered in this chapter, let's examine the subject of maintenance. You have undoubtedly heard that an ounce of prevention is worth a pound of cure. That old saying can be applied aptly to the maintenance of all ordnance weapons, small arms and machine guns in particular.

Preventive maintenance is the systematic care, inspection, and servicing of a piece of equipment. Properly performed, preventive maintenance prevents breakdowns before they happen and assures the gear is in a top state of readiness. Maintenance procedures for small arms and machine guns are set forth on maintenance requirement cards (MRCs). A weapon's TM (technical manual) also provides amplifying maintenance instructions.

Small arms and machine guns should be serviced at three distinct times. First, they must be periodically maintained while they are in stowage. Following the established maintenance schedule for a particular weapon, these periods can range from weekly to annual checks. Second, small arms and machines guns should be serviced before they are used. Third, and maybe most important, they must be serviced immediately after they are fired.

Visual inspections are a vital part of a weapon's maintenance program. During an inspection, make sure all the component parts are in good working order and that they are correctly assembled. Check the tightness of each part and ensure it is adequately lubricated.

The cleanliness and preservation of a weapon are probably the biggest contributing factors to reliable operation and shooting accuracy. Recently a new and improved method of cleaning and preserving gun-barrel bores was introduced to the fleet. This new method involves the use of a Teflon-based liquid called "CLP." It cleans, penetrates, lubricates, and preserves the metal surfaces of a bore. Application of this single solution replaces the old method of cleaning and preserving gun bores. The old method required solvent, soda ash and water, and oil to be applied in separate applications. CLP is more effective and requires about one-half the cleaning time of the old method.

CLP is a blend of Teflon, petroleum distillates, and other chemicals. It does its job by penetrating and breaking loose grit, carbon deposits, and salts from metal surfaces. It preserves surfaces by providing a long-lasting thin film-type protective coating. This thin film, which cures without totally drying, resists moisture, heat, and pressure. It also does not attract dust and powder residue as do some other oils. The lubricating qualities of this material improve maintenance of automatic weapons by reducing friction and wear between moving parts.

CLP is nontoxic and nonirritating to normal skin. It is usable over a wide temperature range. As with many quality products, CLP is expensive. However, large quantities are not required. (A pint of CLP is sufficient to process a 5-inch gun barrel.) CLP's significant cost effectiveness results from its long-lasting and superior performance and decreased processing time. CLP is also marketed as a commercial product under the trade name of Break-free. The Navy has approved CLP for use on all small arms and guns up through the 16-inch. Undoubtedly, additional uses for this product will be found.

We will now discuss the various small arms and machine guns. The major topic areas are:

1. Handguns
2. Shoulder weapons
3. Machine guns
4. Special accessories and devices

HANDGUNS

Today, there are three standard issue handguns used by the Navy. They are the .45-cal semiautomatic pistol (SAP), the .38-cal Smith and Wesson (S&W) revolver, and the .38-cal Ruger service-six revolver.

The .45-cal pistol has been around for a long time. When you serve aboard surface combatant ships, chances are you will encounter this handgun more than the other two. The .38-cal revolvers are mainly found in armories ashore or with the aviation community. The revolvers are popular handguns with personnel assigned to guard or police work and are preferred by our naval aviators. They are favored over the .45-cal pistol because the revolver is lighter. As a Gunner's Mate, you may have to maintain all three types of handguns. Thus, we will discuss each one separately.

THE .45-CALIBER SEMIAUTOMATIC PISTOL (SAP)

During the early 1900s, American troops were called on to fight the Moro tribes in the Philippines. It was found that the tribesmen often were not "stopped" when hit by bullets from .38-cal sidearms. This lack of stopping power was one of the factors which led to the adoption of the .45-cal semiautomatic pistol. In 1911, it was declared the official military sidearm.

The .45-cal semiautomatic pistol, often called the Colt, was designed and patented by John M. Browning. Mr. Browning was probably the world's greatest inventor of automatic weapons. The original 1911 model differs only in minor detail from the current 1911A1 model. Operation of the two pistols is identical. Figure 13-4 shows the pistol with nomenclature for some of the external parts.

The .45-cal M1911A1 pistol is a recoil-operated, semiautomatic, magazine-fed, self-loading handgun with fixed sights. It is often called a .45-cal semiautomatic pistol (SAP) or a .45-cal autoloading Colt (the manufacturer) pistol (ACP). This text will refer to it as a .45-cal pistol.

The magazine holds seven rounds when fully loaded. One round is fired with each squeeze of the trigger. Rifling in the barrel is machined for a left-hand twist (the only Navy weapon with left-hand rifling). Empty, the pistol weighs about 2-1/2 pounds. It has a maximum range of a little over 1,600 yards (1,500 meters) and an effective range of about 50 yards (50 meters).

Disassembly

Care of the pistol includes daily preventive maintenance, prefiring cleaning, and postfiring cleaning. For daily maintenance, the pistol need not be disassembled. For the prefiring and postfiring cleaning, the pistol should be disassembled.

There are two phases of disassembly for the pistol—general disassembly (field-stripping) and detailed disassembly. General disassembly is necessary for normal care, cleaning, and postfiring maintenance. This is the extent of disassembly normally explained to personnel such as watchstanders. The detailed disassembly of the receiver group is the job of the Gunner's Mate during periodic cleaning and repair.

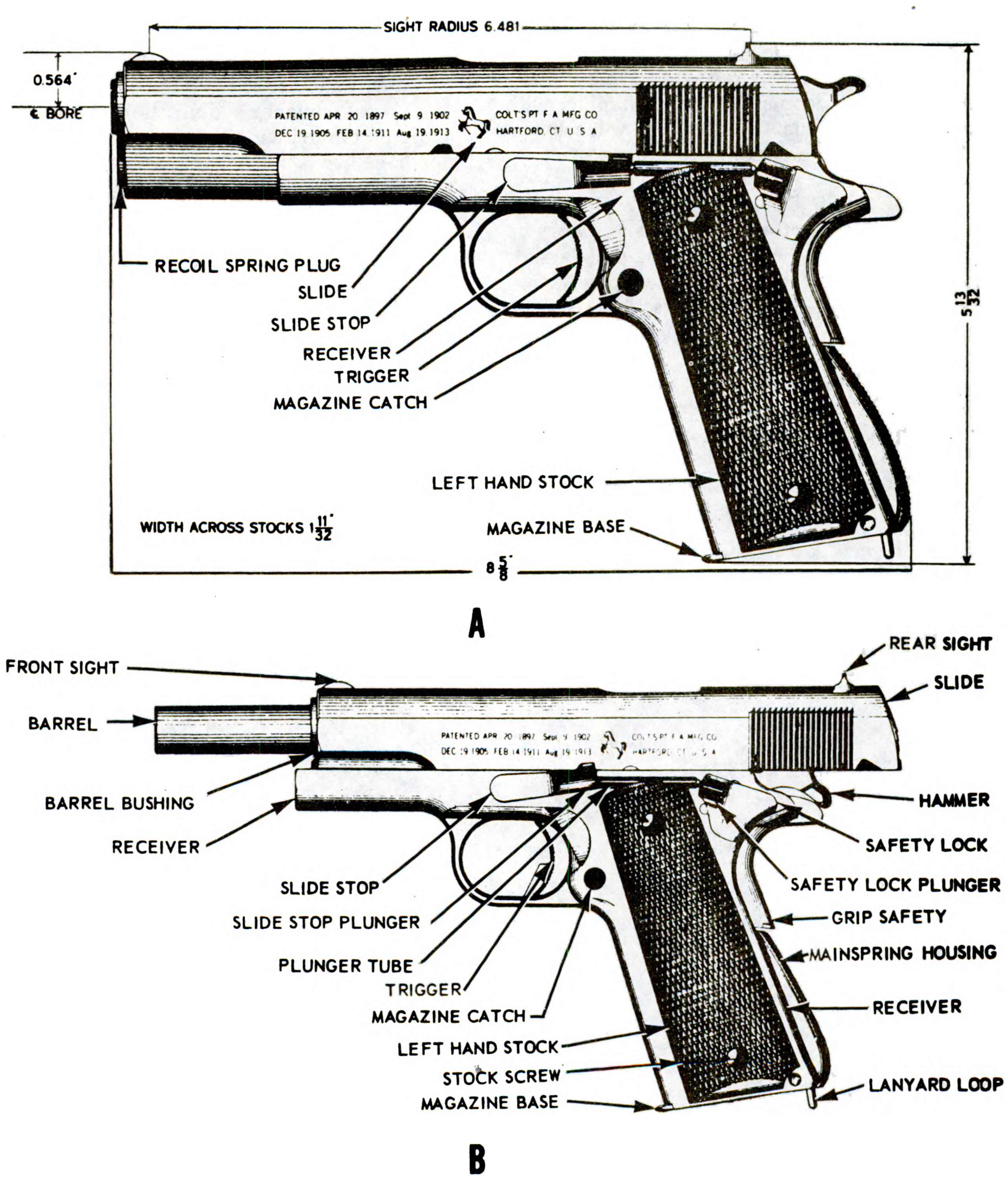

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Figure 13-4.—The .45-cal M1911A1 semiautomatic pistol: A. Slide closed; B. Slide open.

To do a good job of cleaning and repair, you must know the names of the parts of the weapon. Learn these parts while practicing disassembly and assembly. As each part is removed or replaced, say its name. Become thoroughly familiar with each part's individual function. That will help you understand the operation of the weapon.

GENERAL DISASSEMBLY (FIELD-STRIPPING).—Before performing any work on the pistol, remove the magazine and pull the slide to the rear. Inspect to see that the weapon is clear. Refer to figure 13-5 as the text describes the field-stripping steps.

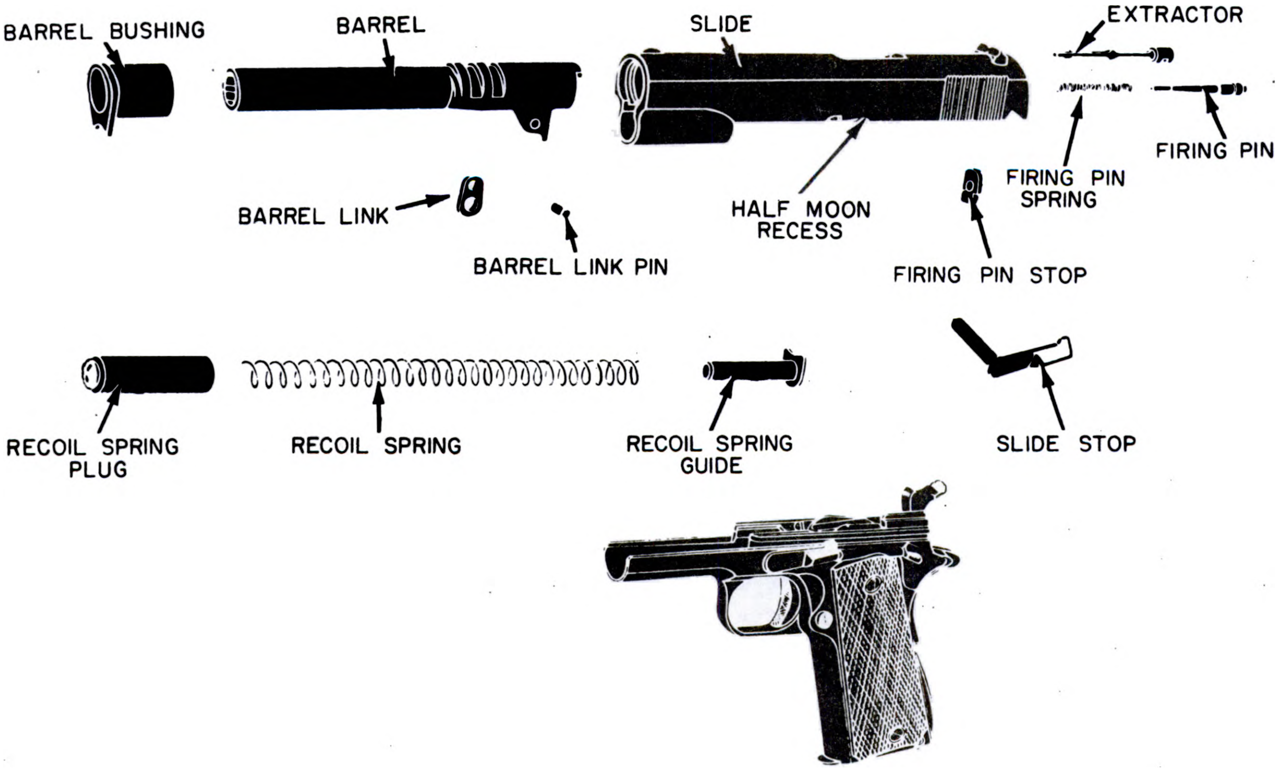
1. Cock the hammer and put the safety lock in its up (SAFE) position. Depress the recoil spring plug. Turn the barrel bushing about a quarter turn clockwise to release the tension on the spring. Allow the spring to expand slowly, under positive control, to prevent injury or loss of parts. Remove the recoil spring and spring plug. Carefully disengage the plug from the spring. Move the safety lock back down to its fire position.

2. Draw the slide to the rear until the half-moon recess (on the slide) is directly above the projection on the slide stop. (This recess, or strip notch, can be seen in figure 13-5.) Push the slide stop out from right to left.

3. Turn the pistol upside down. Draw the receiver to the rear, disengaging it from the slide. Lay the receiver down. Be careful not to let the hammer fall under mainspring tension when the weapon is field-stripped. The force could break or crack the hammer.

4. Draw the recoil spring and the recoil-spring guide to the rear. Remove them from the slide.

5. Take the barrel bushing out of the slide. That is done by turning the bushing counter-clockwise as far as it will go, then lifting up.



17.42.1

Figure 13-5.—The pistol in a field-stripped condition; general disassembly.

6. Rotate the barrel link forward. Pull the barrel out of the muzzle end of the slide.

7. Take the firing pin out by pressing on the rear of the firing pin with any pointed object. Do so until you can slide out the firing pin stop. Keep your fingers over the firing pin, allowing the firing pin spring tension to ease. Now lift both firing pin and spring from the slide.

8. Pry the extractor out from the rear of the slide. That completes the general disassembly procedure for the .45-cal semiautomatic pistol.

DETAILED DISASSEMBLY OF THE RECEIVER GROUP.—Disassembly of the receiver group into its individual parts (illustrated in figure 13-6) is performed as follows:

1. The hammer should be in its cocked position. Move the safety lock up and down. At the same time, pull it outward from the receiver. (Do not use any tool to pry the safety lock out.) With the safety lock removed, squeeze the trigger and allow the hammer to EASE FORWARD.

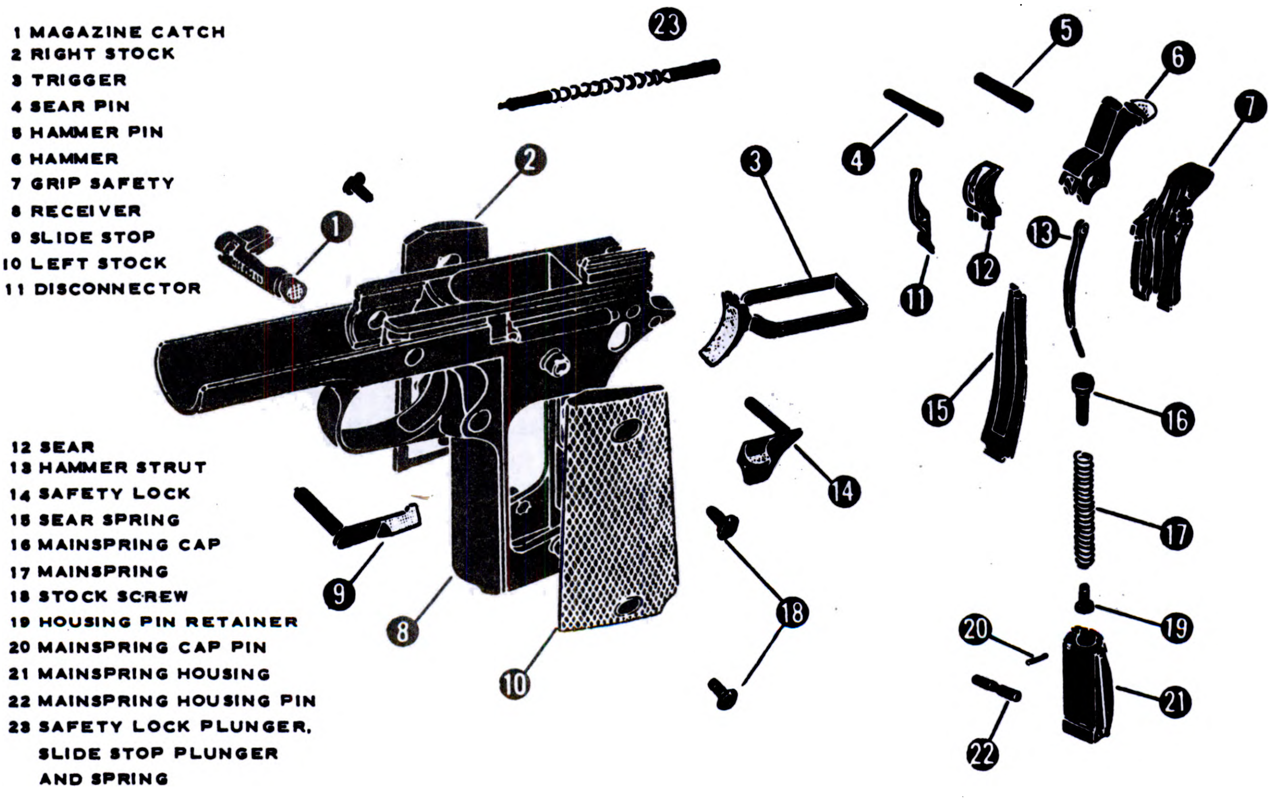
2. Remove the mainspring housing pin. This step requires a good deal of force, so place the receiver on a sturdy work surface. The pin end of the safety lock can be used to push out the mainspring housing pin.

3. Remove the mainspring housing. Take out the grip safety and the sear spring.

4. Using a driftpin, punch out the hammer pin. Lift the hammer from the receiver.

5. Using the driftpin, push the sear pin out from right to left. Let the sear and disconnector drop into your hand.

6. Press the magazine catch in until it is flush with the left side of the receiver. Then, using a suitable screwdriver, turn the magazine catch lock one-quarter turn counterclockwise. Lift the magazine catch from the right side of the receiver.



17.42.2

Figure 13-6.—Receiver group; detailed disassembly.

7. Remove the trigger from the rear of the receiver.

8. Remove the four stock screws and the left and right stocks.

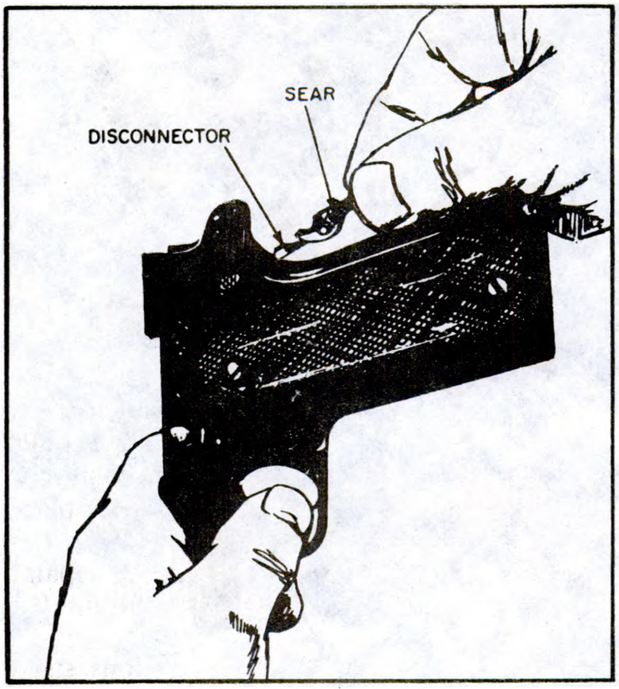
That completes the detailed disassembly procedure. Cleaning and repairing the weapon is then accomplished according to applicable maintenance instructions.

Assembly

Assembly of the weapon is also covered in two phases: First, the receiver group is assembled. At the end of this phase the weapon is in a field-stripped condition. Then the field-stripped weapon is assembled.

Both phases of assembly are done by performing the disassembly procedures in reverse order. Here are some hints which should be helpful in assembling the pistol:

1. All pins go in from left to right.
2. Place the sear and disconnector in as one unit. They should be fitted together as shown in figure 13-7.
3. When you place the sear spring in position, have the mainspring housing ready to slide up about three-quarters of the way into the receiver. The housing will hold the spring in place.
4. Make sure that the hammer strut is actually fitting well down into the mainspring cap before sliding the mainspring housing into place. (Sometimes the hammer strut will catch on top of the cap instead of properly seating in the cap's recess.)
5. The recoil spring has a large and a small end. Make sure the small (or tight) end of the spring is placed over the recoil-spring guide.



17.42.3

Figure 13-7.—Replacing the sear and disconnector.

Safeties

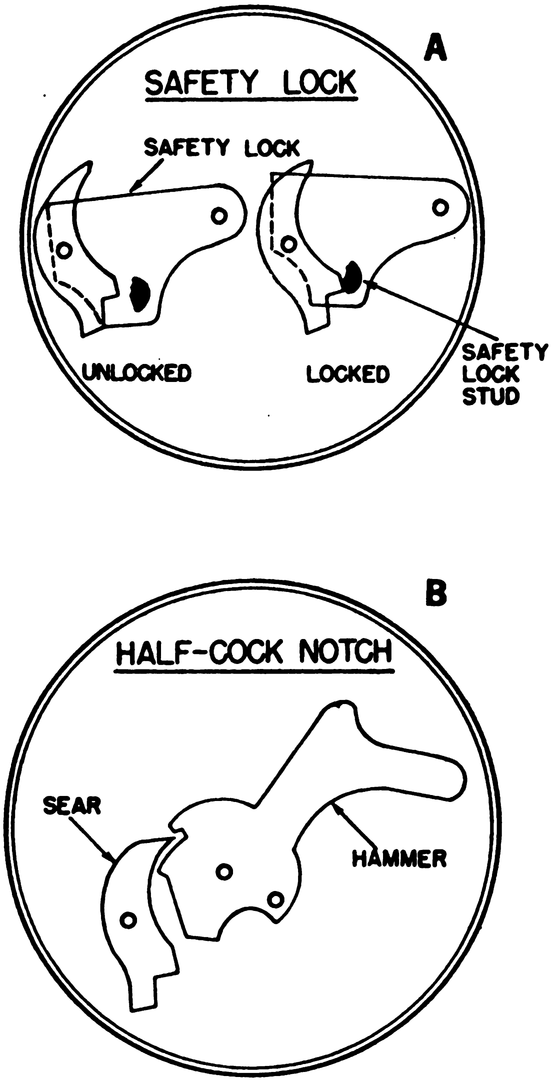
There are three positive safeties on the .45-cal pistol. The two manual safeties are the safety lock (sometimes called the thumb safety) and the half-cock notch. The automatic safety is the grip safety. Although the disconnector is classed as a safety device, it is not considered a positive safety as are the three safeties mentioned above. The disconnector is designed to prevent the pistol from firing if the slide is not fully forward (in battery) and locked.

The safety lock positively locks the slide in the forward position. In addition, a stud on the safety lock (view A of figure 13-8) blocks the shoulders of the sear. This stud prevents any movement of the sear out of the full-cock notch of the hammer.

The half-cock notch is just above the full-cock notch. It has a lip which prevents movement of the sear from the half-cocked position when pressure is applied to the trigger. (See view B of figure 13-8.)

The grip safety (view A of figure 13-9) indirectly stops any movement of the sear by blocking trigger movement. If the trigger cannot be actuated, the sear cannot move and the hammer will not fall.

The disconnector (view B of figure 13-9) prevents firing unless the slide is fully forward and locked. When the slide is not fully forward, the nose of the disconnector is forced downward (disengaged). In this condition, the disconnector spade does not contact the sear when the trigger is pulled. When the trigger is pulled, the disconnector will be pushed to the rear. However,

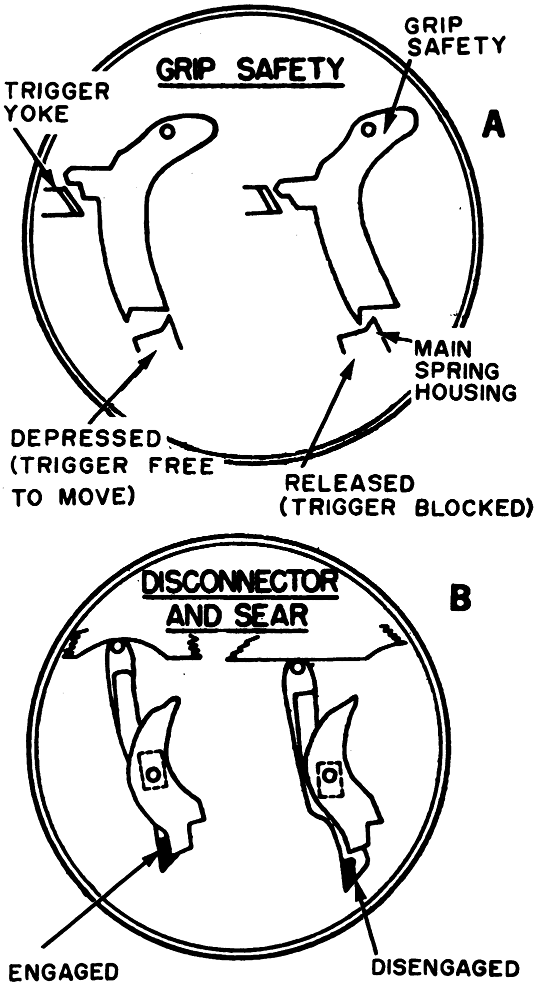


17.42.4

Figure 13-8.—Manual safeties.

the sear remains in position, holding the hammer to the rear.

When the slide is forward, the disconnector rides up (engages) into a recess on the underside of the slide. The spade of the disconnector (dark area) bears against lugs on the sear. When the trigger is pulled, the trigger yoke pushes back against the disconnector spade. The spade transmits this motion to the sear. The sear nose rotates on the full-cock notch of the hammer and the weapon fires.



17.42.5

Figure 13-9.—View A—automatic grip safety; View B—disconnector.

Checking the Safeties

The safeties of the .45-cal pistol are extremely important features of the weapon. They should be checked frequently to ensure continued proper operation. Any defective safety is cause for placing the weapon out of commission. Make the necessary repairs as soon as possible. If repairs cannot be made, tag the weapon unsafe for issue/use and set is aside.

Listed below are a series of actions/steps designed to check each safety feature of the pistol. Ensure the weapon is empty before doing these checks. Also, always point the weapon in a safe direction. When you are familiar with the pistol's operation, these steps can be performed rather quickly. Until you get that experience, do them slowly and deliberately.

Pull the slide to the rear and release it. Press the safety lock up to its safe position. Hold the pistol so the grip safety is depressed and squeeze the trigger three or four times. If the hammer falls, the safety lock is defective and must be replaced.

Continue on by moving the safety lock down to its fire position. Hold the pistol so the grip safety is not depressed. With the hammer fully cocked, squeeze the trigger three or four times. If the hammer falls, the grip safety or sear spring is defective and must be replaced.

Return the hammer to its full forward position. Then pull the hammer rearward only until the sear engages the half-cock notch. With the safety latch on fire and the grip safety depressed, squeeze the trigger three or four times. If the hammer falls, the hammer or the sear is defective and must be replaced.

Now, with your thumb, pull the hammer rearward from the half-cock notch. Move the hammer toward, but do not engage, the full-cock notch. Release the hammer and let it fall. It should fall only to the half-cock notch position. If it goes to the full forward position, the hammer or the sear is defective and must be replaced.

The steps described so far have checked the three positive safeties of the .45-cal pistol. The next series of checks applies to the disconnector. Conduct these checks with the safety lock in fire and the grip safety depressed.

Cock the hammer fully and push the slide about one-quarter inch to the rear. Hold the slide in this position and squeeze the trigger. Nothing should happen at this point. Maintain the pressure on the trigger, and let the slide go all the way forward. If the hammer falls, the disconnector is worn and must be replaced.

Now pull the slide all the way to the rear. Squeeze the trigger and release the slide. The hammer should not fall. If it does fall when the slide is released, the disconnector is worn and must be replaced. Once the slide is fully forward, release the trigger. Then squeeze it again. This time the hammer should fall. The disconnector prevents the release of the hammer until the slide and barrel are fully forward and locked.

Cycle of Operation

Refer to figures 13-4, 13-5, and 13-6 as we explain the functions of the pistol. We will assume that a loaded magazine is in the weapon and a round is in the chamber. The grip safety is depressed. The trigger has been squeezed and a round just fired. The cycle of operation now begins.

As the gases from the burned powder expand, the bullet is forced down the barrel while the same force is directed rearward against the slide. The slide and barrel are locked together at this point and both are forced aft. The barrel link is attached to the stationary receiver. The barrel is moved downward as well as to the rear during this motion. As the barrel locking ribs are disengaged from the recesses in the slide, unlocking is completed.

As the slide moves aft in recoil, the extractor pulls the empty case along with it. Extraction is completed when the cartridge clears the chamber.

Ejection occurs when the cartridge strikes the stationary ejector. The cartridge pivots on the extractor and flips from the weapon through the ejection port.

Cocking began as soon as the slide started its recoil movement. The hammer is moved rearward. The hammer strut is pushed down against the mainspring, compressing it. When the slide strikes the recoil spring guide collar, its rearward movement is stopped. The recoil spring then causes the slide to begin its forward movement. The hammer follows the slide for a short distance. Then the sear, which bears against the hammer through the action of the sear spring, enters the full-cock notch of the hammer. This holds the sear in a cocked position.

Feeding starts as soon as the slide, moving to the rear, clears the top of the magazine. The magazine follower is under pressure from the magazine spring. The follower forces the top round against the lips of the magazine. This places the top cartridge in position to be picked up by the face of the slide during its forward movement.

Chambering occurs when the forward moving slide pushes a new round into the chamber. As the bullet is pushed up the ramp into the chamber, the base of the cartridge slides up the face of the slide. As this happens the groove on the base of the cartridge is engaged by the hooked extractor.

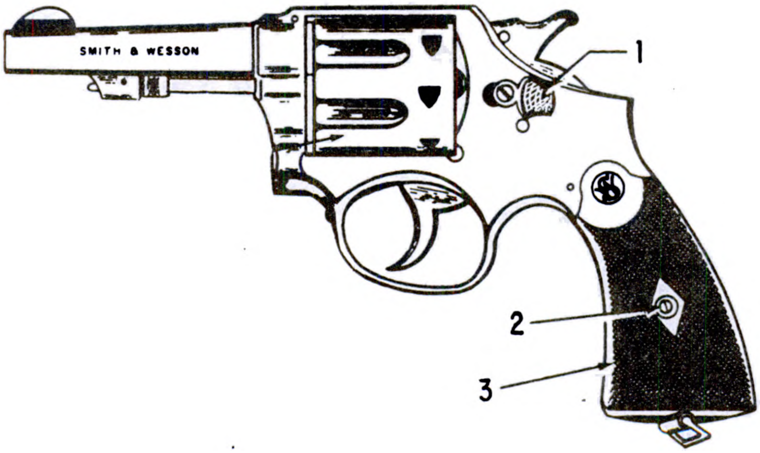
After the round has been chambered, the slide continues forward a short distance, pushing the barrel ahead of it. As the barrel moves, it pivots up and forward on the barrel link. The locking ribs on the barrel enter the locking recesses in the slide. Barrel and slide are locked together again.

Firing will start the cycle all over again. When the grip safety is depressed and the trigger squeezed, the trigger yoke presses against the disconnector. This pushes aft on the sear. The sear rotates on its pin and disengages from the notch on the hammer. The mainspring pushes up on the hammer strut, rotating the hammer forward. The hammer strikes the firing pin. The firing pin strikes the cartridge primer and the pistol goes BANG! (This BANG is rather loud. The wearing of ear protectors is highly recommended.)

THE .38-CAL SMITH AND WESSON (S&W) REVOLVER

The .38-cal S&W revolver with a 4-inch barrel is shown in figure 13-10. The weapon is cylinder loaded, has an exposed hammer, and has selective single- or double-action.

The revolving cylinder has six cartridge chambers and accepts various .38 special ammunition. The action of cocking the hammer causes the cylinder to rotate one chamber at a time. A loaded chamber should be moved in line with the barrel each time the revolver is cocked. If one or more chambers are empty, the closed cylinder can be rotated manually. This is done by holding the hammer at about one-quarter full cock and turning the cylinder. The loaded chamber is stopped when it is one place from in line with the barrel. The next cocking action will move the loaded chamber into firing position.



1. **Thumbpiece (cylinder release).**
2. **Stock screws.**
3. **Stock.**

84.241

Figure 13-10.—The .38-cal Smith and Wesson (S&W) revolver.

Operation

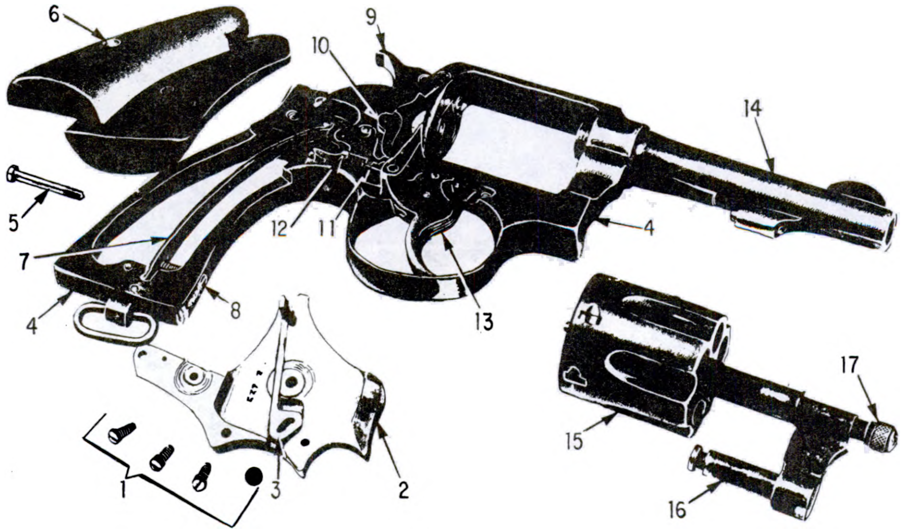
In this discussion, operation of the revolver is limited to loading, firing, and unloading. To load the revolver, the cylinder must be swung out. That is done by pushing forward on the thumbpiece and applying a little pressure to the right side of the cylinder. The thumbpiece will not release the cylinder if the hammer is cocked. Do not flip the cylinder out sharply. That could cause the crane to be bent, which would throw the cylinder out of timing. Insert a round into each of the cylinder's six chambers. Slowly, but firmly, swing the cylinder back into position. The weapon is now loaded and ready to be fired.

The revolver can be fired by single or double action. For single-action firing, the hammer is pulled back with the thumb to the full-cock position for each round. This action also rotates the cylinder. Until released by the trigger, the hammer is held in the cocked position by the sear. In double-action firing, pulling the trigger causes the hammer to be raised to nearly full-cock position. The hammer strut will escape the trigger and the spring-loaded hammer will fall and strike the cartridge. In double-action firing, the cylinder is rotated by pulling the trigger. Since single-action firing requires considerably less trigger pull, this method should produce better accuracy. The empty cartridges are ejected by swinging the cylinder out to the left and moving the extractor plunger toward the rear of the cylinder.

Safeties

The .38-cal revolver does not have manually operated safety devices as did the .45-cal pistol. However, it does have two built-in safety features. They are (1) the hammer block and rebound slide and (2) the cylinder bolt.

The hammer block is functional when the hammer and trigger are in their full forward or



1. **Slide plate screws.**
2. **Sideplate.**
3. **Hammer block.**
4. **Frame.**
5. **Stock screw.**
6. **Stocks.**
7. **Mainspring.**
8. **Mainspring strain screw.**
9. **Hammer.**
10. **Sear.**
11. **Rebound slide.**
12. **Hammer block pin.**
13. **Trigger.**
14. **Barrel.**
15. **Cylinder.**
16. **Crane or yoke.**
17. **Extractor plunger.**

84.241.3

Figure 13-11.—The .38-cal S&W revolver; disassembled.

uncocked positions. The hammer block prevents the hammer from going far enough forward to strike a cartridge primer. If the weapon was dropped or otherwise struck on the hammer, a round could not be fired.

The hammer block also works in conjunction with the rebound slide. The rebound slide actuates (moves) the hammer block as the hammer is being cocked. Should your thumb slip from the hammer during cocking, the hammer block again prevents the hammer from striking a cartridge.

The second safety is the cylinder bolt. It ensures positive chamber-to-barrel alignment each time the cylinder is rotated. The cylinder cannot be swung out when the hammer is cocked. Nor can the weapon be operated if the cylinder is not locked in position. The cylinder bolt locks the cylinder in place and, thus, serves as a safety feature.

Disassembly and Assembly

To disassemble the Smith and Wesson revolver, perform the following steps. Refer to figures 13-10 and 13-11.

1. Remove the stock screws and stocks.

2. Push forward on the thumbpiece (No. 1 in figure 13-10) to actuate the cylinder latch. Swing the cylinder out to the left. With a small screwdriver, remove the sideplate screw located directly under the cylinder. This screw retains the crane (or yoke) of the cylinder and ejector group.

3. Remove the cylinder and ejector group by pulling the cylinder forward.

4. Remove the three remaining sideplate screws.

5. Remove the sideplate. (Do not use excessive force.)

6. If the revolver has a hammer block that fits over a pin in the rebound slide, remove the hammer block. If the revolver has the type of hammer block that is staked to the sideplate (early models), removal is not required.

To reassemble the weapon, if the hammer block has been removed, place the hole in the hammer block over the hammer block pin (No. 12 in figure 13-11). Ensure that the L-projection of the hammer block will fit between the hammer and the frame. Assemble the sideplate, making sure the hammer block fits into the recess on the sideplate. (Do NOT use excessive force.) Install the remaining parts following the reverse order of disassembly.

THE .38-CAL RUGER SERVICE-SIX REVOLVER

The .38-cal Ruger service-six revolver is shown in figure 13-12. It has the same basic physical and functional characteristics as the .38-cal S&W revolver. That includes cylinder loading, exposed hammer, and selective single- or double-action. Cocking operations are performed in a similar manner also. Generally, the two revolvers are identical (almost) and only the part nomenclature has changed.

One distinguishing feature of the .38-cal Ruger is that it uses double side-wall, solid-frame construction. That eliminates the need for a sideplate. (Refer to item 2 in figure 13-11 of the .38-cal S&W revolver.) All internal parts are installed either from the top or bottom of the grip frame.

Operation

The loading, firing, and unloading of the .38-cal Ruger are the same as described with the .38-cal S&W.

Safeties

The .38-cal Ruger incorporates the same two safety features as the .38-cal S&W. On the Ruger, they are called (1) transfer bar and (2) cylinder interlock.

Field-Stripping

No special tools are needed to field-strip or reassemble the .38-cal Ruger revolver. To

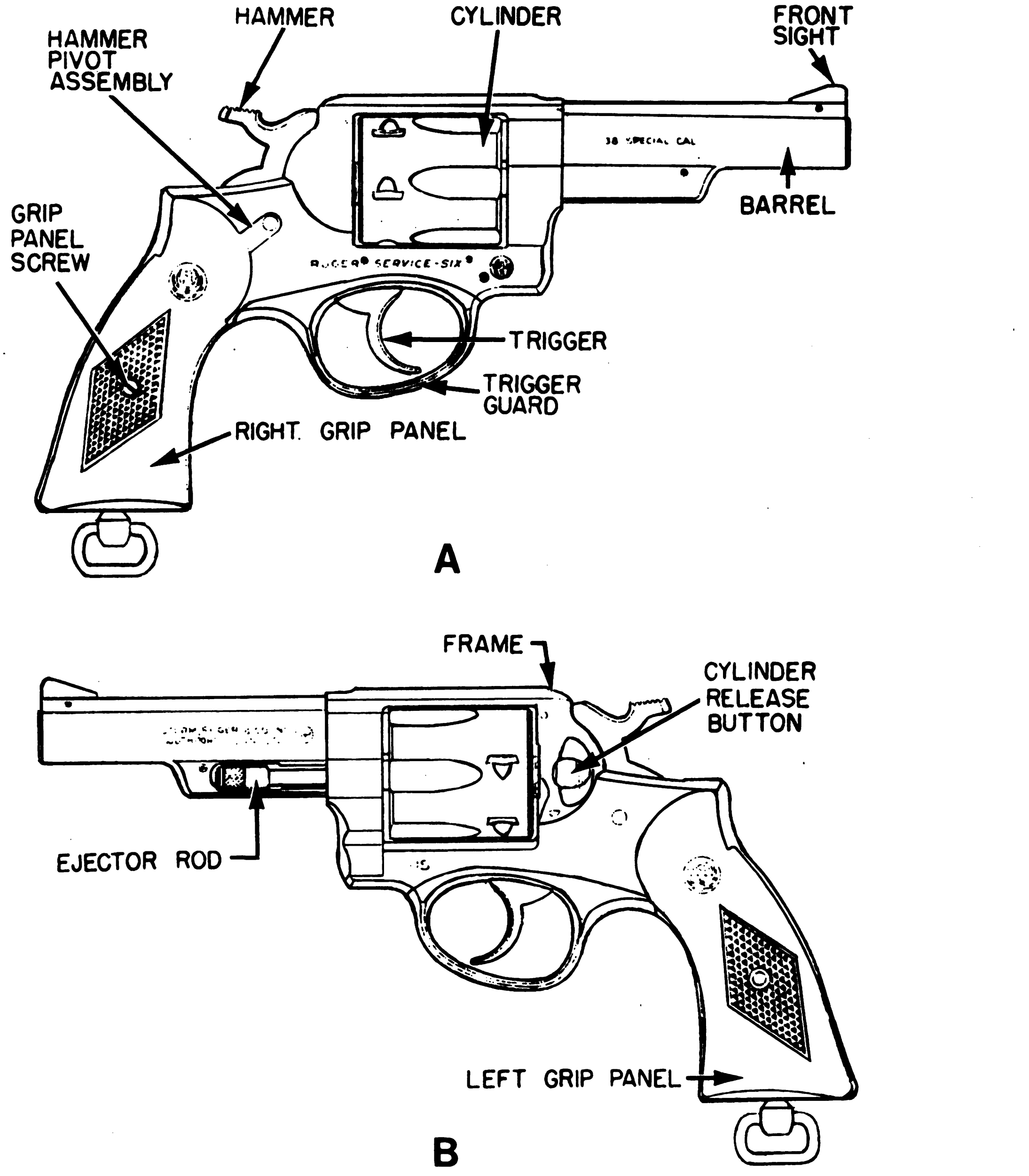


Figure 13-12.—The .38-cal Ruger service-six revolver.

disassemble the weapon, perform the following steps. Refer to figures 13-12 and 13-13.

1. Unload the revolver and close the cylinder.
2. Remove the grip screw and both grip panels. It is best to use a small, proper fitting screwdriver to remove the grip screw.
3. Cock the hammer.
4. Locate and remove the disassembly pin from its stowage position in the grip panel dowel. (See view A of figure 13-13.)
5. Insert the disassembly pin about halfway into the hole in the hammer strut.

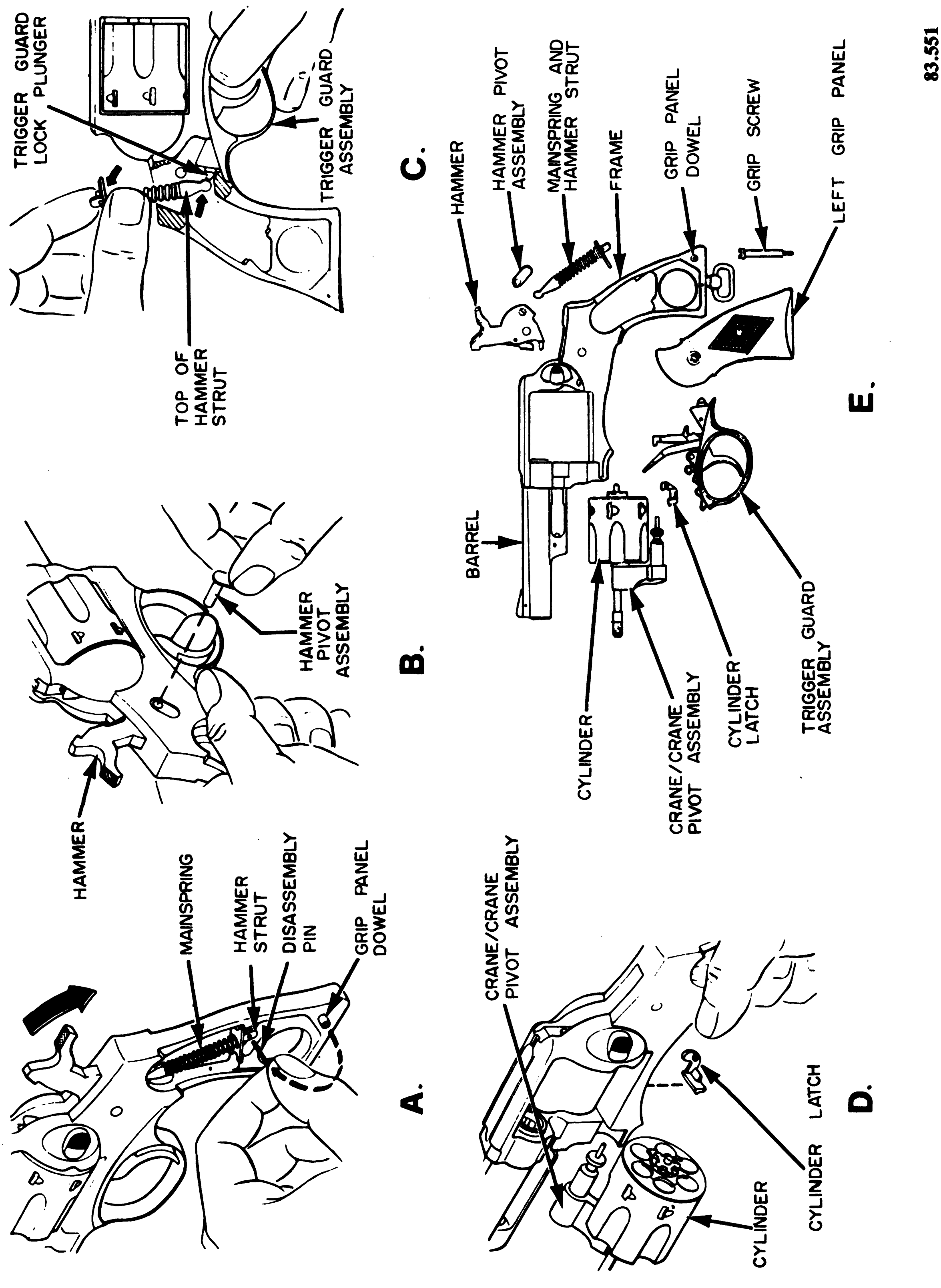


Figure 13-13.—Field-stripping the .38-cal Ruger revolver.

6. Pull the trigger back slightly and remove the mainspring and strut assembly intact. (A small nail or metal pin can be used in place of a lost disassembly pin.)

7. Pull the trigger to the rear and remove the hammer pivot assembly from the right side of the frame. (See view B.)

8. Pull the hammer out from the top of the frame while holding the trigger back slightly.

9. Use the top end of the hammer strut to depress the trigger guard lock plunger. It is located

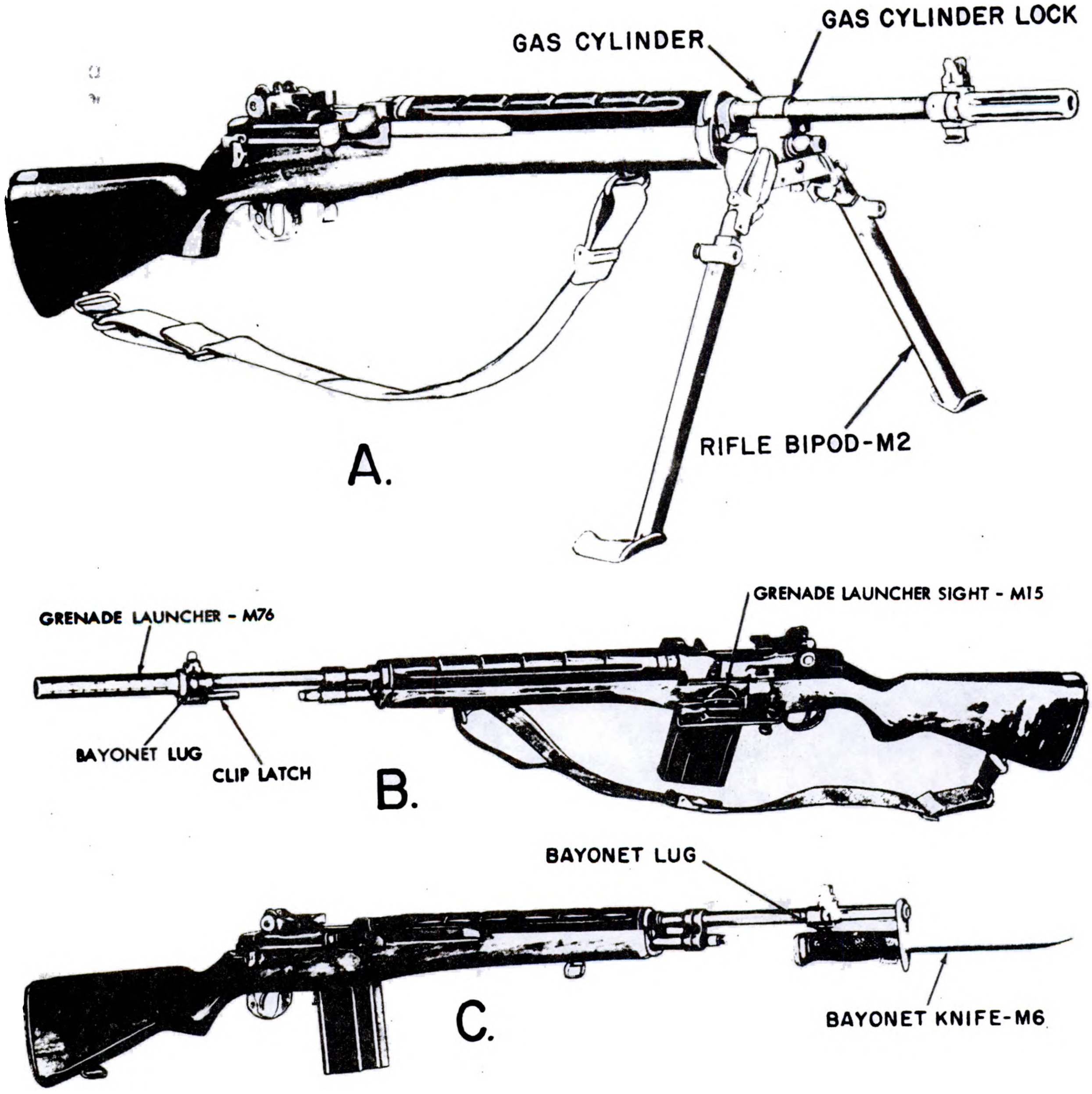


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Figure 13-14.—The 7.62-mm M14 rifle with accessories: A. M2 rifle bipod; B. M76 grenade launcher with M15 grenade launcher sight; C. M6 bayonet knife.

inside the frame at the rear of trigger guard. (See view C.) At the same time, pull down and remove the trigger guard assembly.

10. Open the cylinder. Pull it and the crane/crane pivot assembly from the front of the frame as a unit. (See view D.) Also remove the cylinder latch from the bottom of the frame.

If all went well, you should have something like view E of figure 13-13 in front of you. Further disassembly is not necessary for normal cleaning and maintenance purposes. Detailed disassembly should be performed with the aid of the technical manual for the Ruger, TMSDA84-1. Reassembly procedures are the reverse of disassembly.

SHOULDER WEAPONS

Shoulder weapons are designed to be held with both hands. They are braced against the shoulder to absorb the force of recoil and improve accuracy. The text will discuss only two shoulder weapons in detail—the M14 rifle and the Remington M870 shotgun. There are other shoulder weapons used by the Navy and maintained by Gunner's Mates. Examples are the M16 rifle and the Mossberg model 500 shotgun. The two shoulder weapons we'll study are those you will most likely encounter aboard surface naval vessels.

M14 RIFLE

The M14 rifle (figure 13-14) is a lightweight, air-cooled, gas-operated, magazine-fed shoulder weapon. It is designed for semiautomatic or full automatic fire. Automatic firing can be performed at the cyclic rate of 750 rounds per minute. The rifle is chambered for 7.62-mm cartridges and is designed to accommodate a 20-round cartridge magazine. Figure 13-14 shows the M14 rifle with its standard accessories—M2 bipod, M76 grenade launcher, and M6 bayonet knife.

M14 Rifle Controls

The major controls of the M14 rifle are listed below and identified in figure 13-15.

1. Selector
2. Trigger and sear assembly

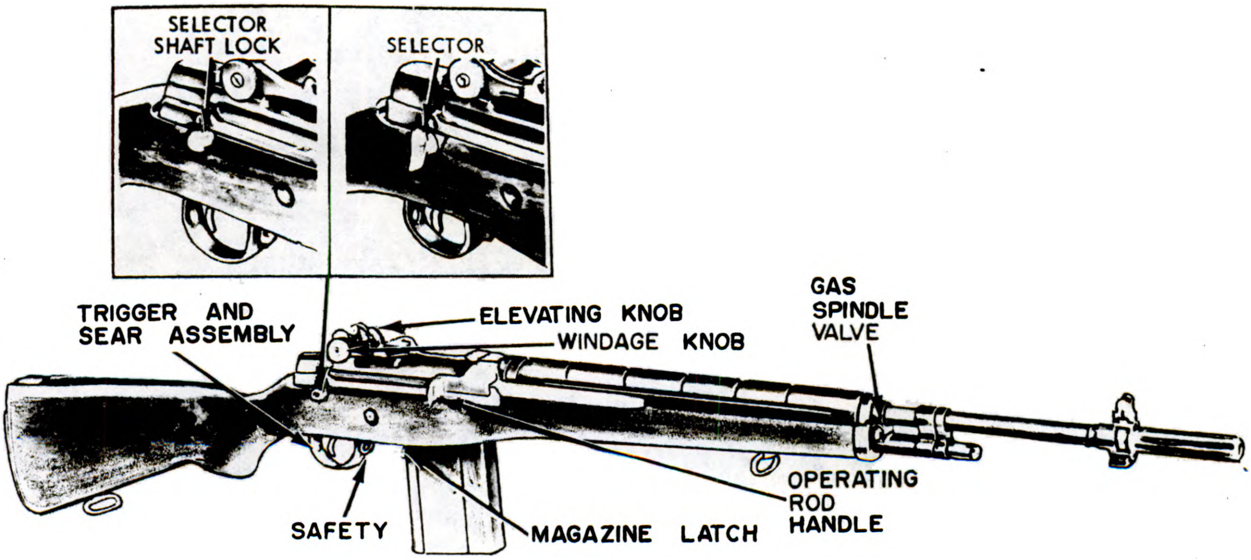

Figure 13-15.—The 7.62-mm M14 rifle and controls.

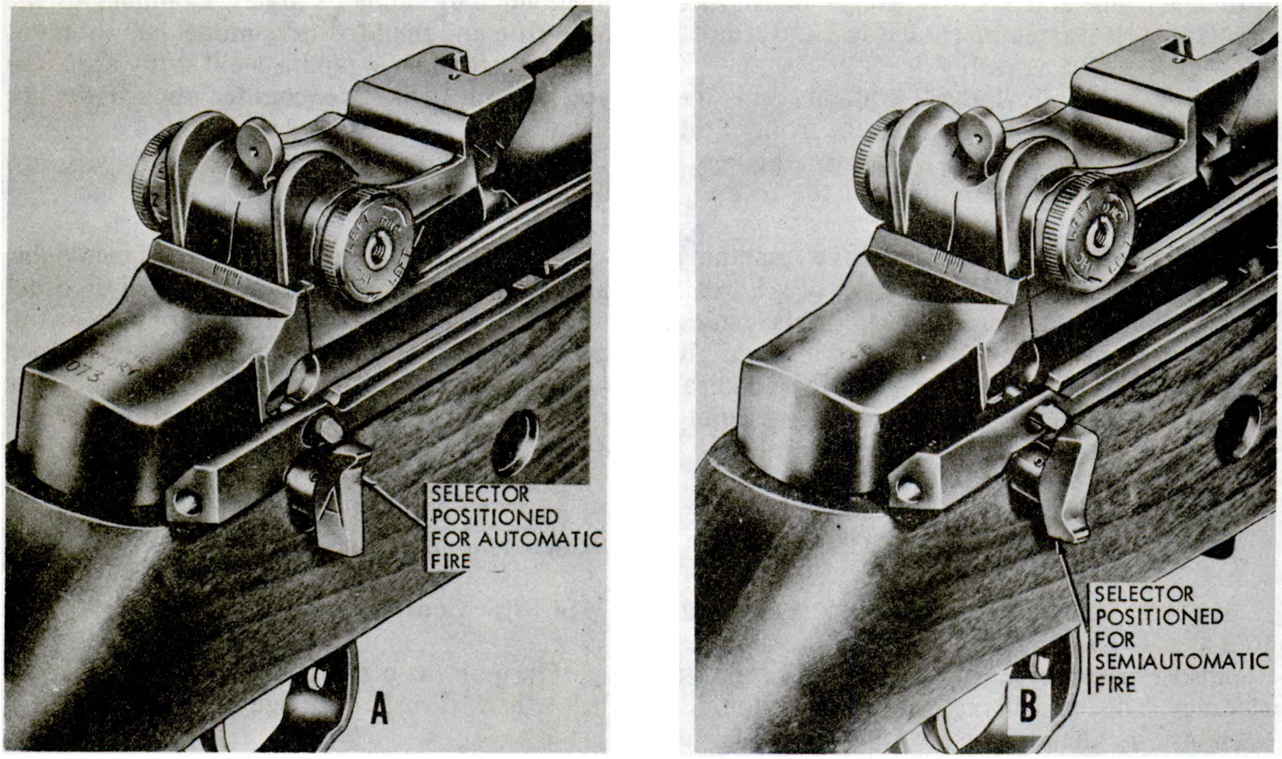
SELECTOR POSITIONED FOR AUTOMATIC FIRE
A
SELECTOR POSITIONED FOR SEMIAUTOMATIC FIRE
B

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Figure 13-16.—Selector positioned for automatic and semiautomatic fire.

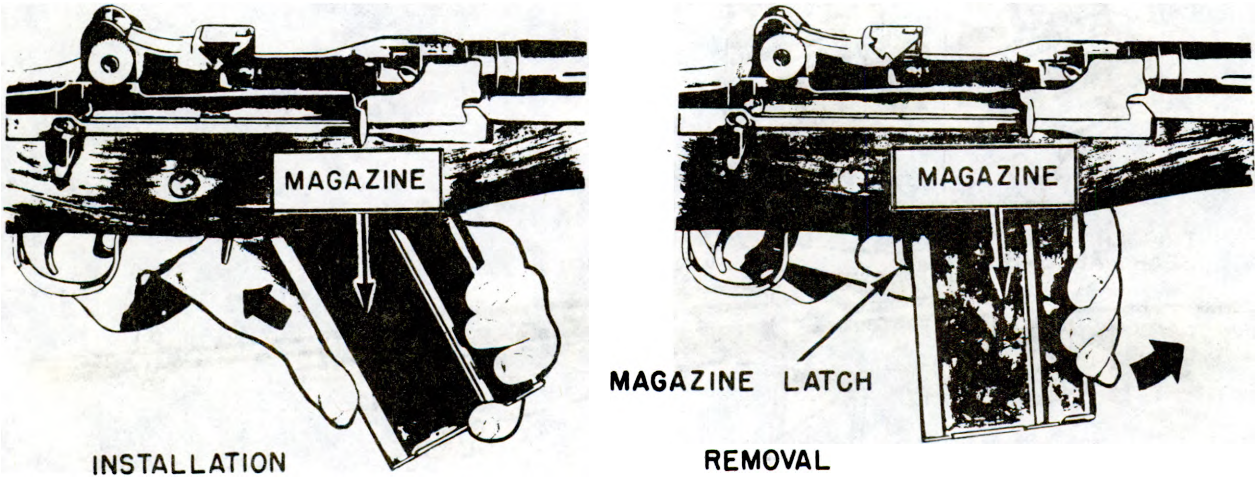

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Figure 13-17.—Installations and removal of magazine.

3. Safety

4. Operating rod handle

5. Magazine and magazine latch

6. Gas spindle valve

7. Rear sight

Figure 13-16 shows the selector positioned for automatic and semiautomatic fire. Most M14 rifles issued to the Navy will not have the automatic fire capability. The selector is removed and a selector shaft lock (seen in figure 13-15) is inserted in its place.

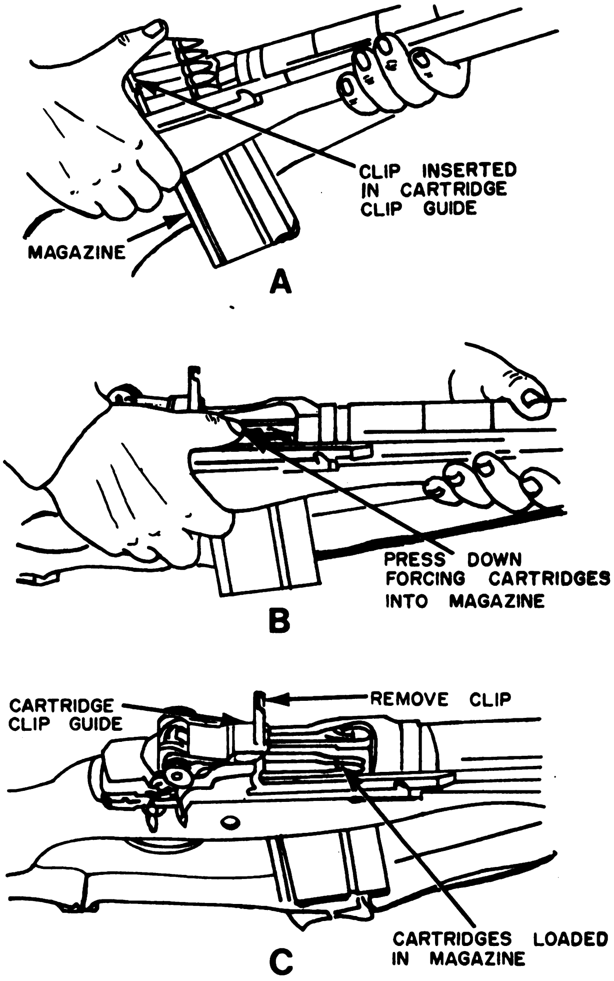
To fire the rifle, you must push the safety forward (seen in figure 13-15) from inside the trigger guard. The trigger is squeezed and released to fire each round in semiautomatic. The trigger is squeezed and held for automatic fire. To safe the rifle, the safety is pulled back into the trigger guard.

The operating rod handle (seen in figure 13-15) of the rifle manually controls the action of the weapon. When pulled to the rear, the operating rod handle opens the bolt and ejects a round. As the operating rod handle moves forward, the bolt goes into battery and chambers a round.

The magazine is capable of holding up to 20 rounds of ammunition (cartridges). Figure 13-17 illustrates how the magazine is installed and removed from the rifle. Installation requires the front end of the magazine be inserted until the front catch (inside the rifle) snaps into engagement. The magazine is then pulled up and back until it is locked in place by the magazine latch. The latch must be depressed to release the magazine. The magazine can be inserted or removed when the operating rod handle is either forward or to the rear.

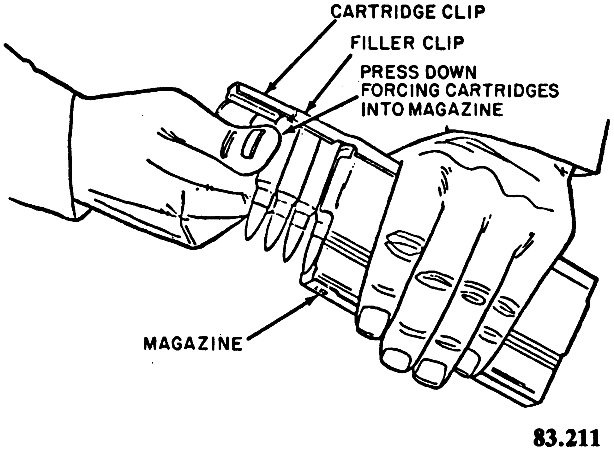
There are two methods of reloading an empty magazine. Figure 13-18 shows the method used with the magazine still in the rifle. That method should be used in the field only, as it creates a possible accidental firing situation.

The first step in this type of reloading is to pull the operating rod handle to the rear. The bolt lock and safety are then engaged. A five-round clip is removed from a bandolier (or belt) and inserted into the cartridge clip guide on the rifle (view A of figure 13-18). The five cartridges are pushed down into the magazine (view B) and the empty clip removed (view C). The operation can be performed three more times (if desired) until the magazine is completely reloaded. To prepare the rifle for firing, the operating rod handle is pulled to the rear again and released. This action frees the bolt lock. As the bolt goes into battery, a cartridge is stripped from the magazine and fed into the chamber.


CLIP INSERTED IN CARTRIDGE CLIP GUIDE
MAGAZINE
A
PRESS DOWN FORCING CARTRIDGES INTO MAGAZINE
B
CARTRIDGE CLIP GUIDE
REMOVE CLIP
CARTRIDGES LOADED IN MAGAZINE
C

29.336

Figure 13-18.—Loading the magazine through the cartridge clip guide; magazine in rifle.


CARTRIDGE CLIP
FILLER CLIP
PRESS DOWN FORCING CARTRIDGES INTO MAGAZINE
MAGAZINE

83.211

Figure 13-19.—Loading the magazine when it is out of the rifle.

The safer method of reloading the magazine is illustrated in figure 13-19. The reason it is safer is obvious—the magazine is removed from the rifle. A magazine loading tool (filler clip) is issued in each bandolier. It is attached to the rear of the magazine and is used to guide the five-round clip. The cartridges are loaded into the magazine as shown in the figure. When the magazine is fully loaded, the filler clip is removed and you're ready for action.

The gas spindle valve (figure 13-20) of the M14 rifle controls the gas used in firing operations. When the slot of the spindle valve is in the vertical or on position (as shown in the upper view of figure 13-20), the valve is open. Gases from a fired round are directed to the gas piston for normal functioning of the rifle. When the spindle valve is in the horizontal or off position (as shown in the lower view of figure 13-20), the spindle valve is closed. This permits the full pressure of the gas to be used in propelling a rifle grenade or line-throwing projectile. (Near the end of the chapter, the text will cover the line-throwing projectile kit used with the M14 rifle.)

The rear sight controls can be seen in figures 13-15 and 13-16. The windage knob is used to adjust the sight laterally. Turning the knob clockwise moves the sight to the right, counterclockwise moves it left. The pinion assembly (or elevating knob) adjusts the sight aperture vertically. Turning the pinion clockwise raises the sight, counterclockwise lowers it.

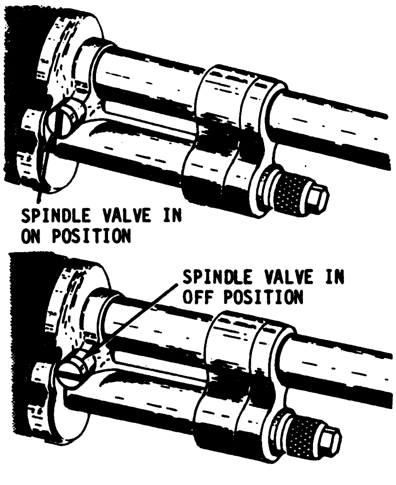


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Figure 13-20.—Gas spindle valve in its on and off positions.

Firing the M14 Rifle

The M14 rifle can be fired in three conditions. If the rifle is equipped with a selector lock shaft, only semiautomatic fire is possible. Simply push the safety forward and squeeze the trigger for each round. If the rifle has a selector, it must be turned to the semiautomatic position. After the safety is released, each squeeze of the trigger will fire one round.

To fire the rifle in automatic, turn the selector to its automatic position. After the safety is released, squeeze and hold the trigger. Firing will continue until the magazine is empty or the trigger is released.

The magazine contains a spring-driven plate called the magazine follower. It is the follower that forces cartridges upward as rounds are expended and the empty cases are ejected. After the last round in the magazine is fired, the follower activates the bolt lock. It holds the bolt in the rearward position.

After an empty magazine is removed and a full one inserted, the bolt lock must be released. That is accomplished by drawing the operating rod handle to the rear. Releasing the operating rod handle closes the bolt and the top cartridge in the magazine is rammed into the chamber.

Unloading the M14 Rifle

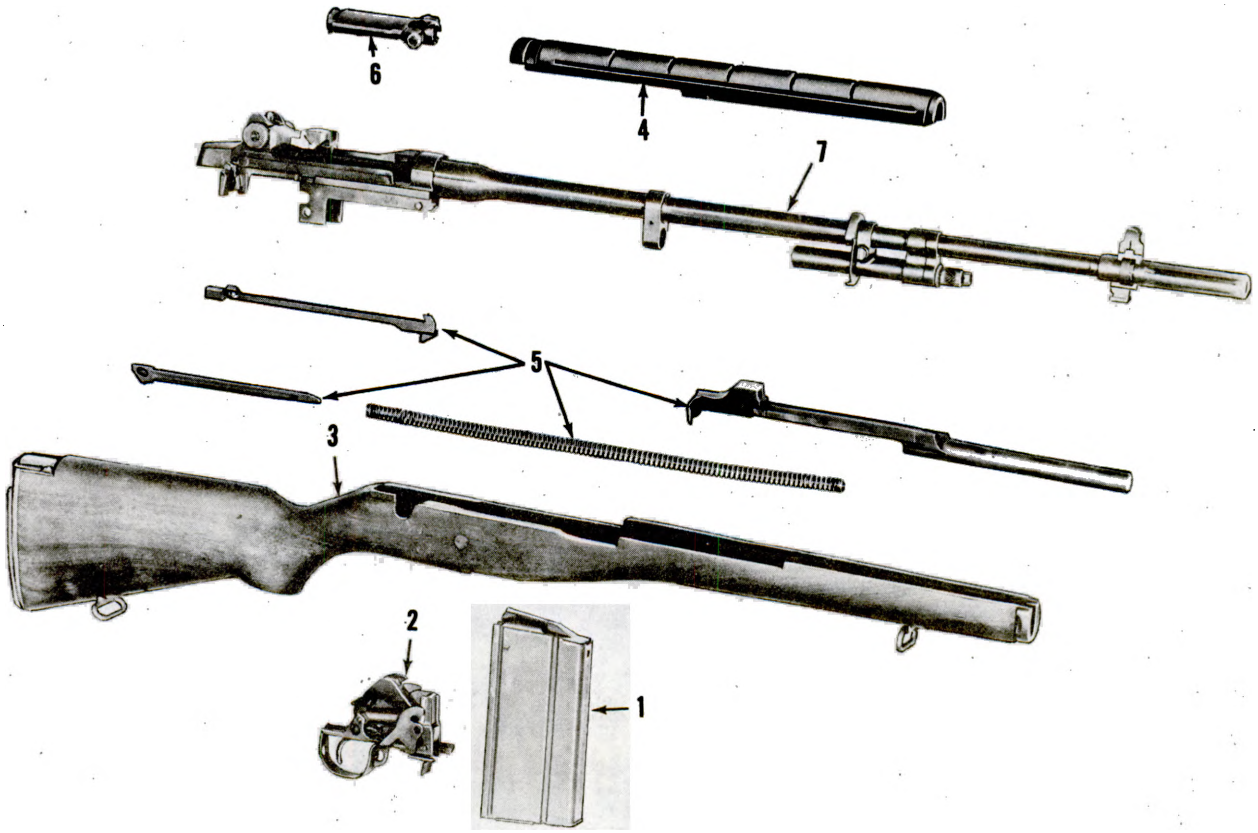
To unload the M14 rifle, proceed as follows:

1. Push the safety to the safe (back) position.
2. Grasp the magazine with your thumb on the magazine latch. Squeeze the latch to release the magazine. Push the magazine forward and downward to disengage it from the front catch. Remove it from the magazine well, as shown in the right-hand view of figure 13-17.
3. Pull the operating rod handle all the way to the rear. Reach across the rifle with your thumb and press in on the bolt lock (or bolt catch). This locks the bolt to the rear.
4. Inspect the chamber to ensure it is clear.

The rifle is clear ONLY when no round is in the chamber, the magazine is out, the bolt is locked to the rear, and the safety is on the safe position (to the rear).

Field-Stripping the M14 Rifle

Figure 13-21 shows how the M14 rifle breaks down into seven group assemblies. You should be



1. **Magazine.**
2. **Firing mechanism.**
3. **Stock with butt plate assembly.**
4. **Hand guard assembly.**
5. **Operating rod and connector group.**
6. **Bolt assembly.**
7. **Barrel and receiver group.**

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Figure 13-21.—Group assemblies of the M14 rifle.

able to disassemble the rifle to this extent for cleaning, lubrication, and maintenance. This procedure is called field-stripping the rifle. The names of the group assemblies are as follows:

1. Magazine
2. Firing mechanism
3. Stock with butt plate assembly
4. Hand guard assembly
5. Operating rod and connector group
6. Bolt assembly
7. Barrel and receiver group

To withdraw the firing mechanism (No. 2 in figure 13-21) from the stock, proceed as follows:

1. Remove the magazine.
2. Place the safety in the safe position after ensuring the rifle is cocked. Place the rifle upside down on a flat surface.
3. Disengage the hooked end of the trigger guard from the firing mechanism housing.
4. Swing the trigger guard up from the stock but do not rotate it more than 90°. Pull it straight up from the stock and draw out the firing mechanism.

After the firing mechanism is removed, the stock with butt plate assembly can be removed. Proceed as follows:

1. Separate the stock with butt plate assembly from the rifle by grasping the receiver firmly with one hand. Strike the butt of the stock sharply with the palm of the other hand.
2. Lift the stock from the barrel and receiver group.

To separate the operating rod and connector group from the barrel and receiver group, proceed as follows:

1. Turn the barrel and receiver group on its side with the connector assembly upward.
2. If the rifle has a selector, press in and turn the selector until the face marked "A" is toward the rear of the sight knob. The projection will be at about a 35° angle. Remove the connector

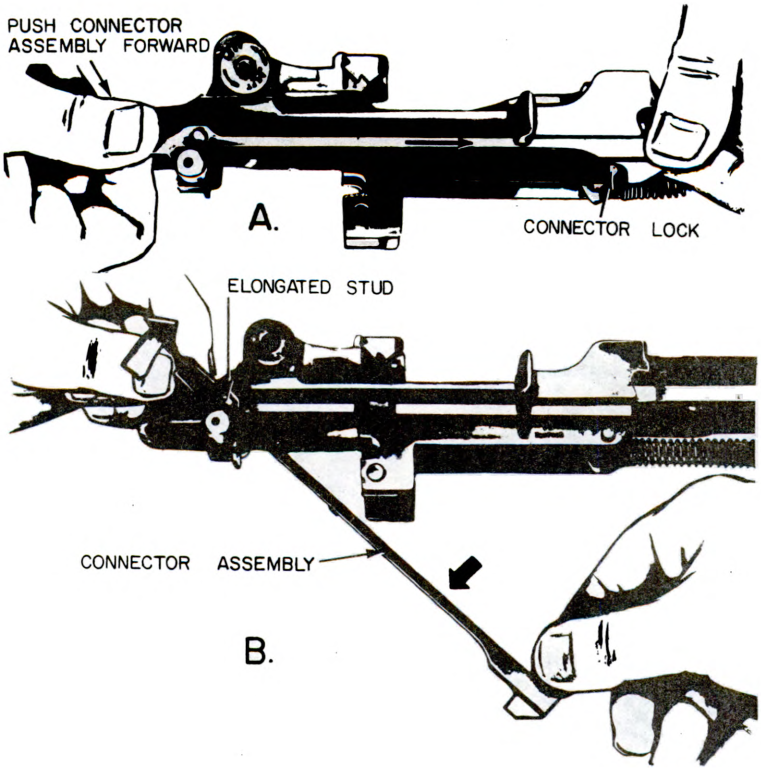


Figure 13-22.—View A—disengaging the connector assembly; View B—removing the connector assembly.

assembly as indicated in paragraphs 3 and 4 below.

3. If the rifle has a selector shaft lock, press forward on the rear of the connector assembly with your right thumb. (See view A of figure 13-22.) Do so until the front end can be lifted off the connector lock.

4. Rotate the connector assembly about 35° clockwise. The slot at the rear will be aligned with the elongated stud on the sear release. See view B of figure 13-22. Lower the front end of the connector assembly and lift it off the sear release.

The next step is to remove the operating rod spring guide, the operating rod spring, and the operating rod. These items are numbered 2, 3, and 4 respectively in figure 13-23. The operating rod spring and spring guide are under very strong tension. Be very careful when removing and installing these parts. Proceed as follows:

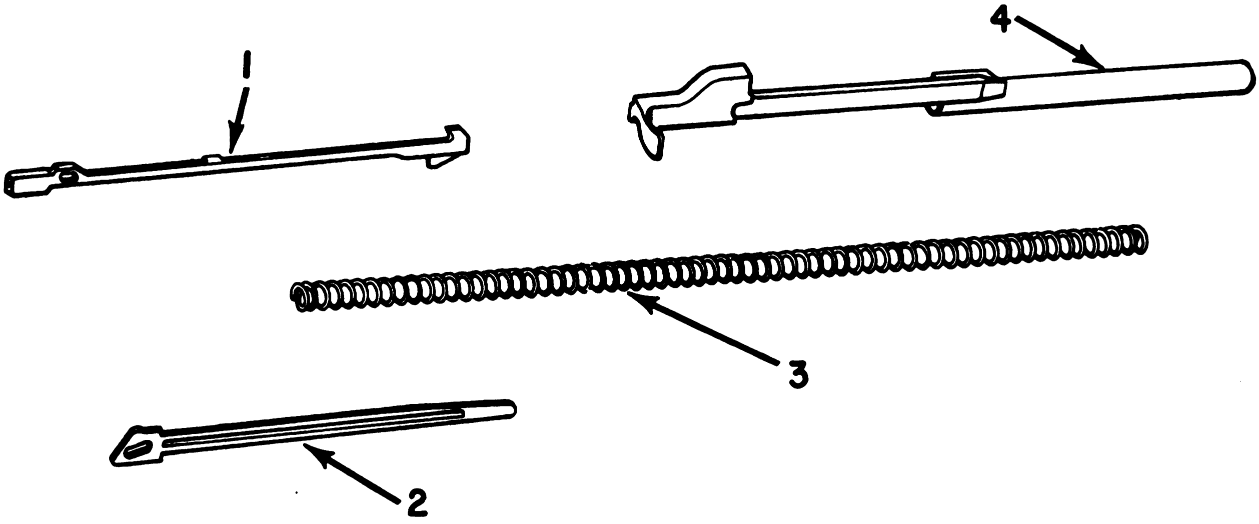
1. With the barrel and receiver group upside down, push forward on the operating rod spring. This relieves the pressure on the connector lock (seen in view A of figure 13-22). Pull the connector lock outward to disconnect the operating rod spring guide.

2. Remove the operating rod spring guide and operating rod spring. Turn the barrel and receiver group right side up.

3. Retract the operating rod until the key on its lower surface coincides with the notch in the receiver. Lift the operating rod free and pull it to the rear. This disengages it from the operating rod guide.

After the operating rod is removed, the bolt can be removed. Grasp the bolt roller that engages with the operating rod and slide it forward. Lift upward and outward to the right with a slight rotating motion. This removes the bolt from the receiver.

Reassembly of this weapon is basically the reverse of disassembly. A step-by-step procedure for reassembly is covered in FM 23-8.



1. CONNECTOR ASSEMBLY
2. OPERATING ROD SPRING GUIDE
3. OPERATING ROD SPRING
4. OPERATING ROD

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Figure 13-23.—Component parts of the operating rod and connector group.

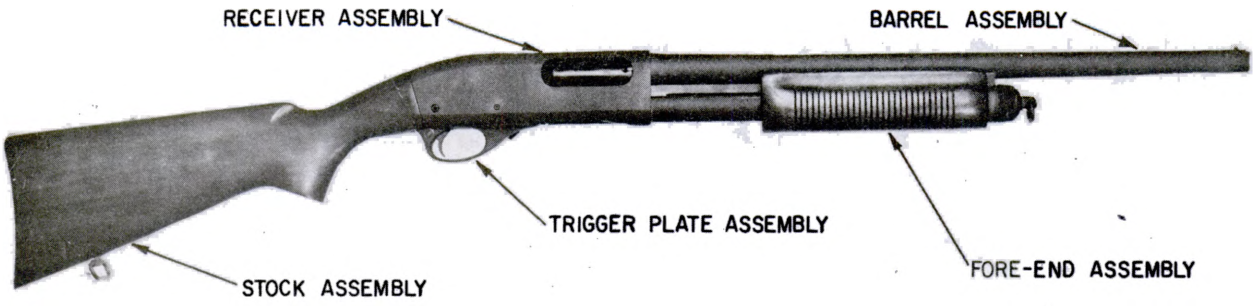

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Figure 13-24.—The M870 Remington shotgun.

THE REMINGTON M870 SHOTGUN

Shotguns used by the Armed Forces are military versions of civilian models. These weapons must meet certain specifications established by the branch of service letting or issuing the contract. The Remington model 870 (M870) and the Mossberg model 500 (M500) are the Navy's standard issue riot-type shotguns. In this chapter, only the Remington M870 (figure 13-24) is described.

The M870 shotgun is used by the Navy for guard work. It is a manually operated, magazine-fed (tubular), pump-action shoulder weapon. The main characteristics of the weapon are listed below.

Length of shotgun......	39 inches (approximately)
Length of barrel........	20 inches
Magazine capacity......	4 rounds
Shell (gauge)...........	12
Ammunition	12 gauge 2-3/4 inch 00 buck, military round
Safety	Cross bolt type
Fore-end...............	Plain beaver tail style

Functioning of the Remington M870

The procedures for operating the M870 shotgun are discussed in the paragraphs that follow.

SAFETY.—Before loading or unloading, push the safety (figure 13-25) across the rear of the trigger by moving it left to right. In the safe position, a red band on the safety will not be visible.

FIRE POSITION.—Push the safety across to the fire position (the red band on the safety will show). The trigger can then be pulled to fire the gun.

SINGLE LOAD.—Push the safety to the safe position. Press in the action bar lock (seen in figure 13-25) and pull the fore-end assembly fully to the rear. Place a shell into the open ejection port. The shell will rest on the carrier at this time.

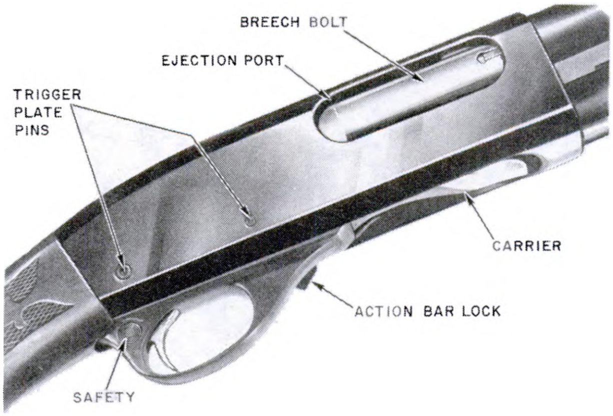

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Figure 13-25.—Receiver nomenclature.

Slide the fore-end toward the muzzle to load the shell into the barrel chamber and lock the action closed. (The term "action" refers to the moving or operating parts of the gun.)

MAGAZINE LOAD.—Push the safety to the safe position. Slide the fore-end completely forward to close the action. Turn the gun bottom upward. Press a shell against the carrier and move it fully forward into the magazine. Make sure that the rim of the shell snaps past the shell latch. This latch prevents the shell from sliding back over the carrier. Should the problem occur, open the action to remove the shell. It may be necessary to remove the trigger plate assembly (figure 13-26) if the gun is cocked. Continue this operation until the magazine is full.

LOADING THE BARREL FROM THE MAGAZINE.—Shells can be fed from the loaded magazine by simply pumping the fore-end. Press in the action bar lock if the gun is cocked. Pump the fore-end back and forth to open and close the action.

UNLOADING THE GUN.—Push the safety to the safe position and press in the action bar lock. Pull the fore-end slowly rearward. Do so until the front end of the shell is even with the ejection port in the receiver. Lift the front of the shell outward and remove it from the ejection port. Continue pulling the fore-end back fully until the next shell releases from the magazine. Roll the gun sideways to allow the released shell to drop from the ejection port. Close the action by pushing forward on the fore-end. Continue this sequence until the magazine and gun are empty.

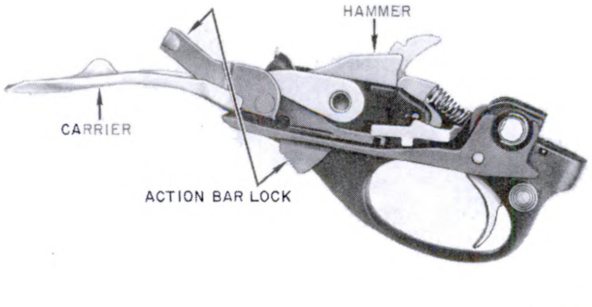

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Figure 13-26.—Trigger plate assembly.

CAUTION: Open the action and check the shell chamber in the breech and magazine to make sure no rounds remain in the gun.

UNLOADING THE BARREL ONLY.—Push the safety to the safe position and press in the action bar lock. Pull the fore-end rearward. Do so until the front end of the shell from the barrel is even with the front end of the ejection port. Lift the shell from the receiver as described previously. A shell with a different powder and shot combination may then be placed in the chamber and the action closed without disturbing the other shells in the magazine.

M870 Shotgun Disassembly

The following discussion on the disassembly of the M870 shotgun covers only the steps necessary for routine servicing of the weapon. Refer to figures 13-27 and 13-28 (individual parts breakdown and accompanying parts list) to become familiar with the location and names of the shotgun's components.

The first step in disassembling the M870 shotgun is to ensure no shells are in the chamber or the magazine.

BARREL.—To remove and clean the barrel, push the safety to the safe position and open the action. Unscrew the magazine cap and pull the barrel from the receiver. Replace the magazine cap on the end of the magazine tube. To clean the barrel, use a cleaning rod with a lightly soaked cloth of CLP to scrub the bore. Replace the barrel by removing the magazine cap and insert the barrel into the receiver. Replace the magazine cap as the last step.

TRIGGER PLATE ASSEMBLY.—With the safety pushed to the safe position, cock the action. Tap out the front and rear trigger plate pins. Lift the rear of the trigger plate from the receiver and slide it rearward to remove it from the gun. When replacing the assembly in the gun, make sure the action bar lock enters the receiver easily and operates in position.

FORE-END ASSEMBLY UNIT.—Push the safety to the safe position. Close the action and remove the magazine cap and barrel. Reach into

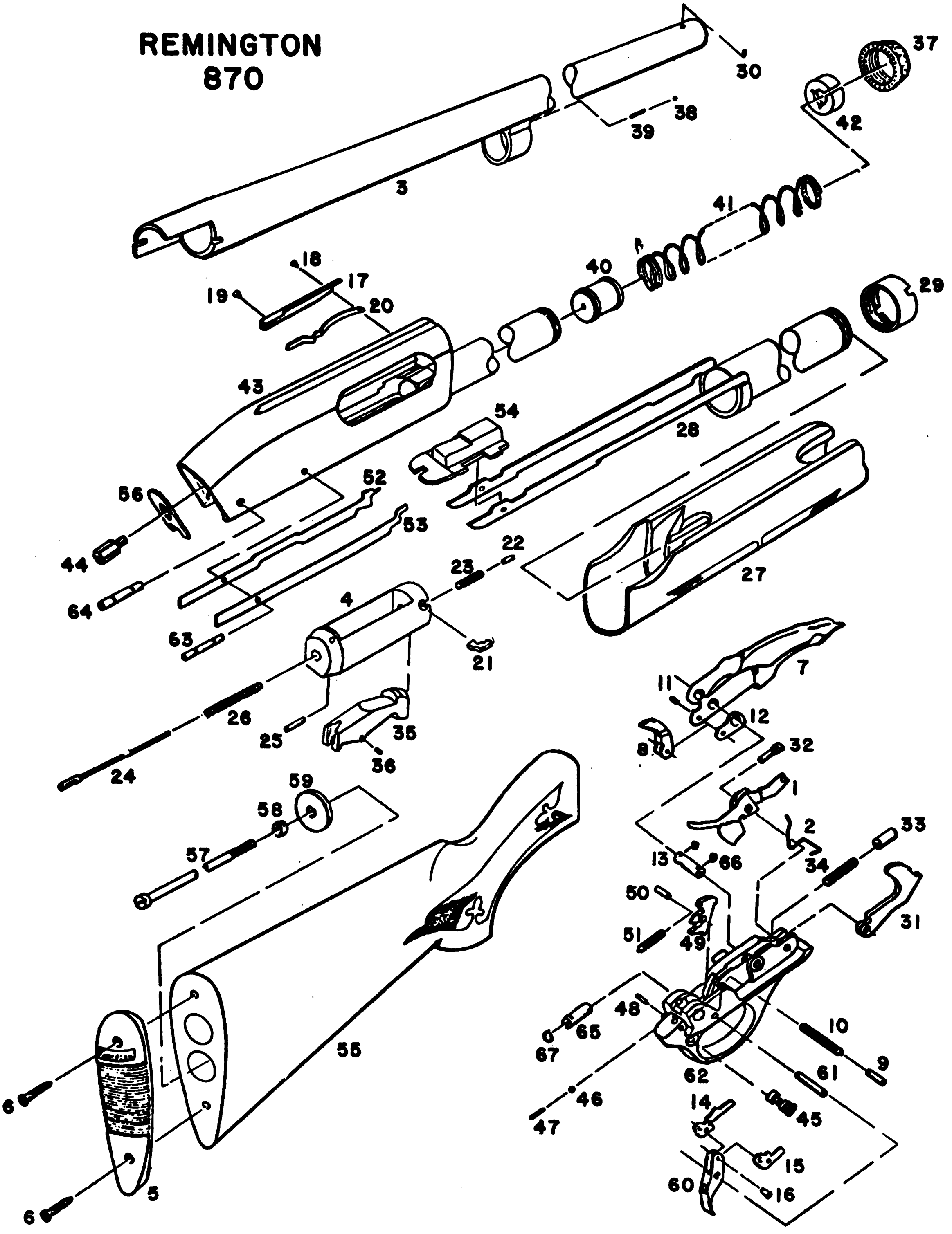

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Figure 13-27.—The M870 Remington individual parts breakdown.

View No.	NAME OF PART
1	Action Bar Lock
2	Action Bar Lock Spring
3	Barrel Assembly, 12 Ga. PLAIN, 20" (includes Barrel, Barrel Guide Ring, Barrel Guide Pin Front Sight (Steel), Magazine Cap Detent, Magazine Cap Detent Spring)
4	Breech Bolt, 12 GA.
	Breech Bolt Assembly, Complete, 12 Ga., (includes Breech Bolt, Extractor, Extractor Plunger, Extractor Spring, Firing Pin, Firing Pin Retaining Pin, Firing Pin Retractor Spring, Locking Block Assembly, Slide)
5	Butt Plate
6	Butt Plate Screw
7	Carrier
	Carrier Assembly, (includes Carrier, Carrier Dog, Carrier Dog Pin, Carrier Dog Washer)
8	Carrier Dog
9	Carrier Dog Follower
10	Carrier Dog Follower Spring
11	Carrier Dog Pin
12	Carrier Dog Washer
13	Carrier Pivot Tube
14	Connector, Left
15	Connector, Right
16	Connector Pin
17	Ejector, 12 Ga.
18	Ejector Rivet, Front
19	Ejector Rivet, Rear
20	Ejector Spring
21	Extractor
22	Extractor Plunger
23	Extractor Spring
24	Firing Pin
25	Firing Pin Retaining Pin
26	Firing Pin Retractor Spring
	Fore-end (Wood only) 12 Ga.
27	Fore-end Assembly, 12 Ga. (includes Fore-end, Fore-end Tube Assembly, Fore-end Tube Nut)
28	Fore-end Tube Assembly (includes Action Bar, Left; Action Bar, Right; Fore-end Tube)
29	Fore-end Tube Nut
30	Front Sight (Plain Barrel)
	Front Sight (Vent Rib) Steel Bead
	Front Sight Retaining Pin (for use on Vent Rib Steel Sight)
31	Hammer
32	Hammer Pin
	Hammer Pin Washer
33	Hammer Plunger
34	Hammer Spring
35	Locking Block Assembly (includes Locking Block, Locking Block Stud)
	Locking Block Assembly (oversize)
36	Locking Block Stud
37	Magazine Cap
38	Magazine Cap Detent
39	Magazine Cap Detent Spring
40	Magazine Follower, 12 Ga.
41	Magazine Spring
42	Magazine Spring Retainer
43	Receiver Assembly, 12 Ga. (includes Receiver, Ejector, Ejector Rivet, Front; Ejector Rivet, Rear; Ejector Spring, Magazine Tube, Barrel Support)
44	Receiver Stud
45	Safety
46	Safety Detent Ball
47	Safety Spring
48	Safety Spring Retaining Pin
49	Sear
50	Sear Pin
51	Sear Spring
52	Shell Latch, Left, 12 Ga.
53	Shell Latch, Right, 12 Ga.
54	Slide
55	Stock Assembly (includes Stock, Grip Cap, Grip Cap Screw, Butt Plate, Butt Plate Screws (2)
56	Stock Bearing Plate
57	Stock Bolt
58	Stock Bolt Lock Washer
59	Stock Bolt Washer
60	Trigger
	Trigger Assembly (includes Trigger, Connector, Left; Connector, Right; Connector Pin)
61	Trigger Pin
62	Trigger Plate, R.H. (Right Hand Safety)
	Trigger Plate, L.H.
	Trigger Plate Assembly, R.H. (includes Action Bar Lock Action Bar Lock Spring, Carrier, Carrier Dog, Carrier Dog Follower, Carrier Dog Follower Spring, Carrier Dog Pin, Carrier Dog Washer, Carrier Pivot Tube, Connector Left; Connector right; Connector Pin, Hammer, Hammer Pin, Hammer Pin Washer, Hammer Plunger, Hammer Spring, Safety, Safety Plunger, Safety Spring, Safety Spring Retaining Pin, Sear, Sear Pin, Sear Spring Trigger, Trigger Pin, Trigger Plate, R.H.; Trigger Plate Pin Bushing, Trigger Plate Pin Detent Springs, From (2); Trigger Plate Detent Spring, Rear)
	Trigger Plate Assembly, (L.H. Safe)
63	Trigger Plate Pin, Front
64	Trigger Plate Pin, Rear
65	Trigger Plate Pin Bushing
66	Trigger Plate Pin Detent Spring, Front
67	Trigger Plate Pin, Pin Detent Spring, Rear

84.359

Figure 13-28.—The M870 Remington parts list.

the bottom of the receiver and press the left shell latch inward. Remove the fore-end by sliding it forward off the magazine tube. After the fore-end assembly has been removed from the gun, the breech bolt parts and slide may be lifted from the ends of the action bars.

NOTE: The top right edge of the slide may bind on the bottom front edge of the ejector port in the receiver. To free the slide, push downward on the front end of the bolt.

It is not necessary to disassemble the bolt for routine cleaning.

M870 Shotgun Assembly

Assembly of the weapon is done in reverse of disassembly. There are, however, set procedures to follow. When assembling the fore-end parts, the gun must be cocked. Place the slide in the correct position on the ends of the double-action bar. Place the breech bolt assembly, which includes the attached locking block assembly, over the slide on the action bars. Insert the end of the action bars into the matching grooves in the receiver. Move the fore-end slowly until contact is made with the front end of the right shell latch. Press the front right shell latch into the side of the receiver. Continue moving the fore-end past this latch until contact is made with the left shell latch. Press the front of the left shell latch in to allow the fore-end assembly to pass and move freely into the receiver. Assemble the barrel to the receiver and tighten firmly with the magazine cap. This completes the assembly of the shotgun.

MACHINE GUNS

A typical machine gun is an automatic weapon which uses the larger calibers of small arms ammunition. The machine gun provides a heavy volume of close, accurate, and continuous fire for both offensive and defensive purposes. Machine guns are usually heavier than shoulder weapons. Therefore, they are normally mounted on a bipod or tripod device to increase their accuracy. The text will cover two types of machine guns—the .50-caliber Browning and the 7.62-mm M60.

THE .50-CALIBER BROWNING MACHINE GUN

Browning machine guns (BMGs) are standard Army weapons used throughout the Navy. The .50-cal BMG issued to naval activities is designated the M2. The weapon is available with two types of barrels. An aluminum alloy "light" barrel is used for the aircraft version of the .50-cal BMG, M2. A "heavy barrel" (HB) is issued for ship/surface craft use. Our discussion centers around the .50-cal BMG, M2HB (figure 13-29).

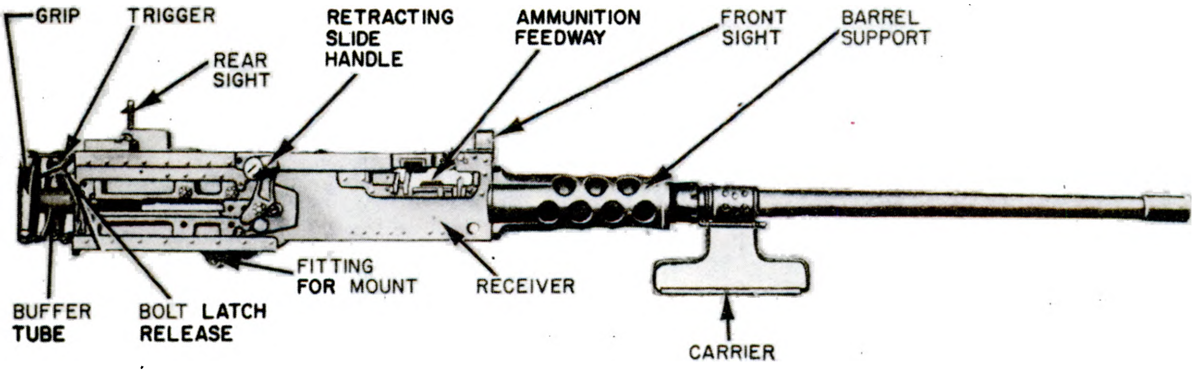

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Figure 13-29.—The .50-cal Browning machine gun (BMG), M2HB.

General Description

The .50-cal BMG is a belt-fed, crew-operated, recoil-operated, air-cooled weapon. It can be fired in automatic and semiautomatic. The .50-cal BMG does not have any positive safeties.

Ammunition is supplied to the gun's receiver (ammunition feedway) by a disintegrating metallic link belt. The BMG is capable of alternate feed. Normally, the gun is fed from its left side. But, by repositioning certain component parts, the belt may be fed from the right side.

One person can operate the .50-cal BMG. However, two people, the gunner and assistant gunner, are normally used. The gunner actually fires the weapon. The assistant gunner helps to load/reload the ammunition into the receiver. Other personnel—ammunition bearers—can be used to keep the assistant gunner supplied. Speed, skill, and teamwork are important.

The force for recoil is furnished by the expanding gases of the fired cartridges. The recoil operation is controlled by various springs, cams, and levers within the gun.

Air-cooling of the .50-cal BMG is permitted by exposing most of the barrel and receiver to the air. Perforations (holes) in the barrel support allow air to circulate around the breech end of the barrel. A heavy barrel (HB) is used to retard or slow down early overheating.

The .50-cal BMG has a leaf-type rear sight. It is graduated in both yards and mils for ranges from 100 to 2,600 yards and from 0 to 62 mils. A windage knob permits deflection changes of 5 mils right or left of center. The front sight is a semifixed blade type with a cover.

Because of its size and weight, the .50-cal BMG usually needs some type of mounting support. Figure 13-30 illustrates the M3 tripod mount arrangement. You may encounter other devices or stands. The primary reason for mounting the weapon is to increase its firing accuracy. (Of course, if you think you are John Wayne, go ahead and shoot from the hip!)

The main characteristics of the .50-cal BMG are listed below:

Weight of receiver group	60 lb.
Weight of barrel	24 lb. (approx.)
Weight of tripod mount M3 (w/traversing and elevating mechanism and pintle w/bolt)	44 lb.
Total weight of gun, complete, on tripod mount, M3	128 lb. (approx.)
Maximum range (M2 ball)	6,800 meters (approx.)
Maximum effective range	1,830 meters
Rates of fire:	
Sustained	40 rd. or less per min.
Rapid	40 rd. or more per min.
Cyclic rate of fire	450-550 rd. per min.
Muzzle velocity (M2 ball)	3,050 ft/sec (2,080 mph)
Length of gun, overall	65 in. (approx.)
Length of barrel	45 in.

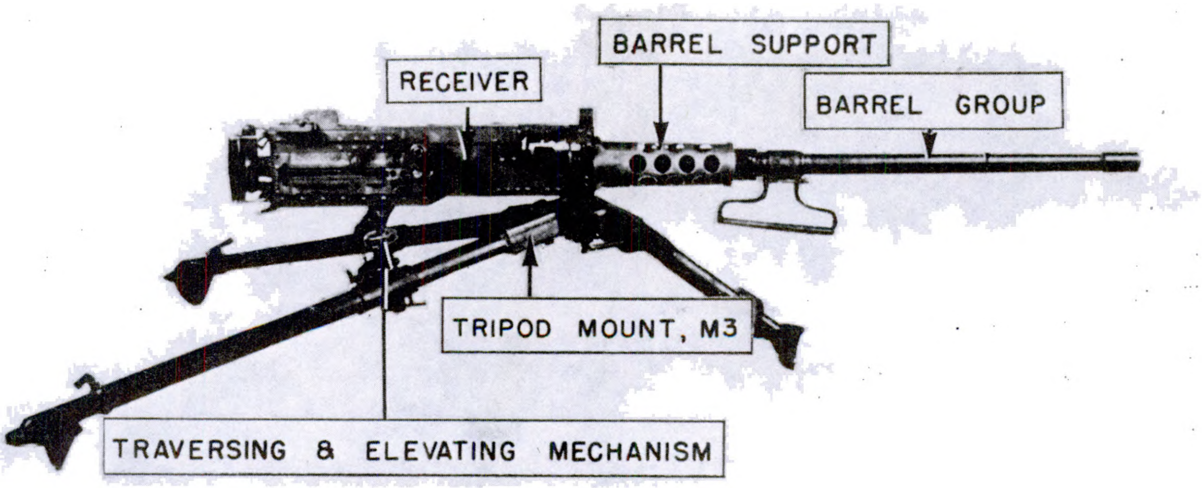

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Figure 13-30.—The .50-cal BMG on an M3 tripod mount.

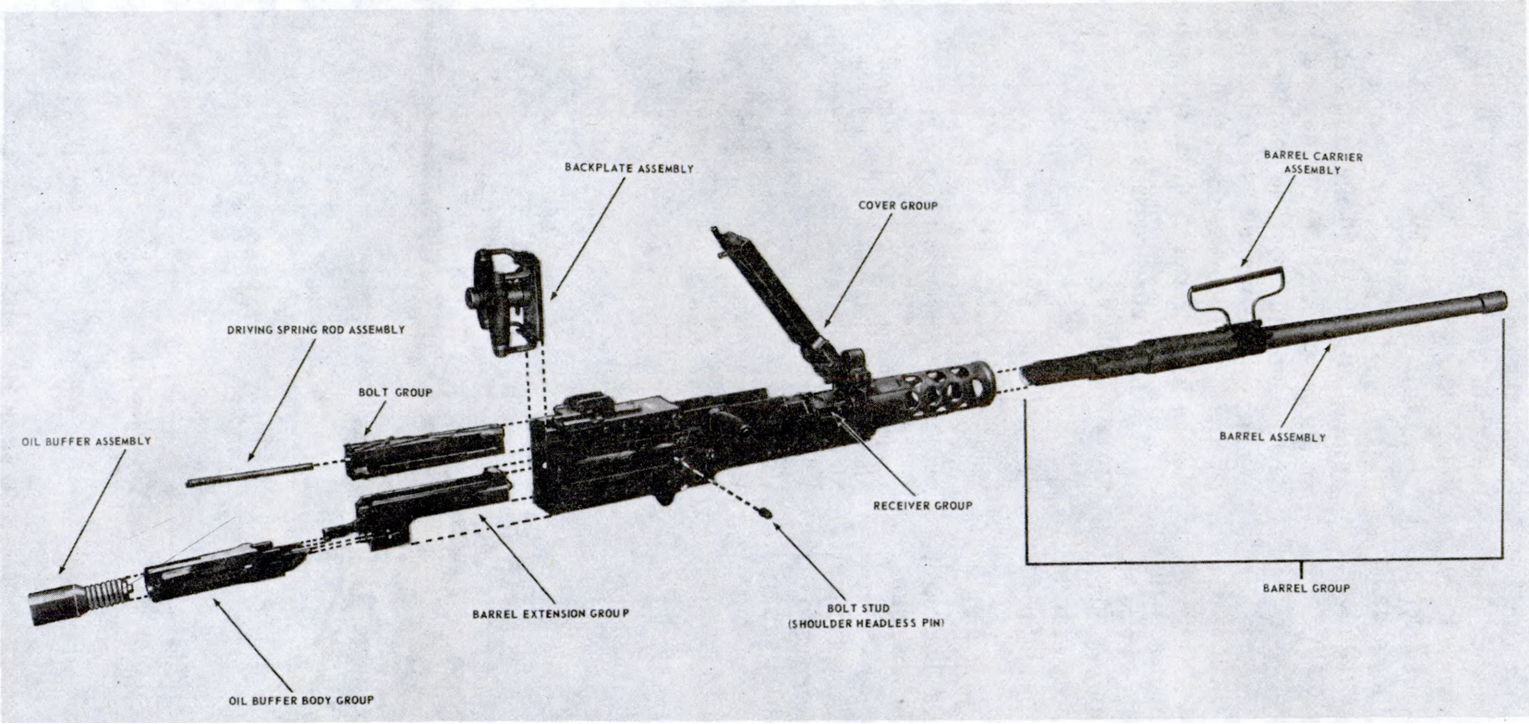

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Figure 13-31.—Major component groups and assemblies.

General Disassembly

Figure 13-31 illustrates the major component groups and assemblies of the .50-cal BMG. For routine cleaning and maintenance, you need to know the general disassembly procedures. Detailed disassembly procedures remove all parts from each group. These steps are explained in the Army's FM23-65. Be sure to consult the field manual if you must do a detailed disassembly.

Before starting general disassembly procedures, the weapon must be cleared. This includes ensuring the gun is unloaded, cocked, and the bolt is forward. The primary steps involve removal of the—

1. Barrel group
2. Backplate assembly
3. Driving spring rod assembly
4. Bolt stud
5. Bolt group
6. Oil buffer body and barrel extension groups
7. Oil buffer assembly

REMOVE BARREL GROUP.—The actions required to remove the barrel group are illustrated in figure 13-32. Turn the cover latch lever forward and raise the cover group (view A). Pull the retracting slide (bolt) handle to the rear slowly (view B). That moves the gun's recoiling parts to the rear.

Pull rearward until the lug on the barrel locking spring aligns with a 3/8-inch hole. The hole is in the right sideplate of the receiver, just below the feedway exit. The barrel can be turned only when the lug is aligned with the 3/8-inch hole. Place the smallest loop of a .50-cal belt link (or suitable spacer) between the trunnion block and the barrel extension. This holds the barrel locking spring lug aligned with the 3/8-inch hole in the right sideplate (view C).

Now, unscrew the barrel from the receiver (view D). Be careful not to damage the threads or barrel-locking notches when setting the barrel down. Complete this phase of disassembly by pulling back slightly on the retracting slide handle. Then remove the .50-cal link (or spacer) from the receiver. Do not allow the bolt to slam forward with the barrel removed. You will cause damage. Let the retracting slide handle (and bolt) ease forward carefully.

REMOVE BACKPLATE ASSEMBLY.—To remove the backplate assembly, refer to figure 13-33. Two conditions must exist before the backplate assembly can be removed. First, the bolt latch release must be up and free of the bolt latch release lock. If it is not, push down on the bolt latch release. (See view A of figure 13-33.) Turn the buffer tube sleeve to the right. Keep turning until the bolt latch release lock is free of the bolt latch release.

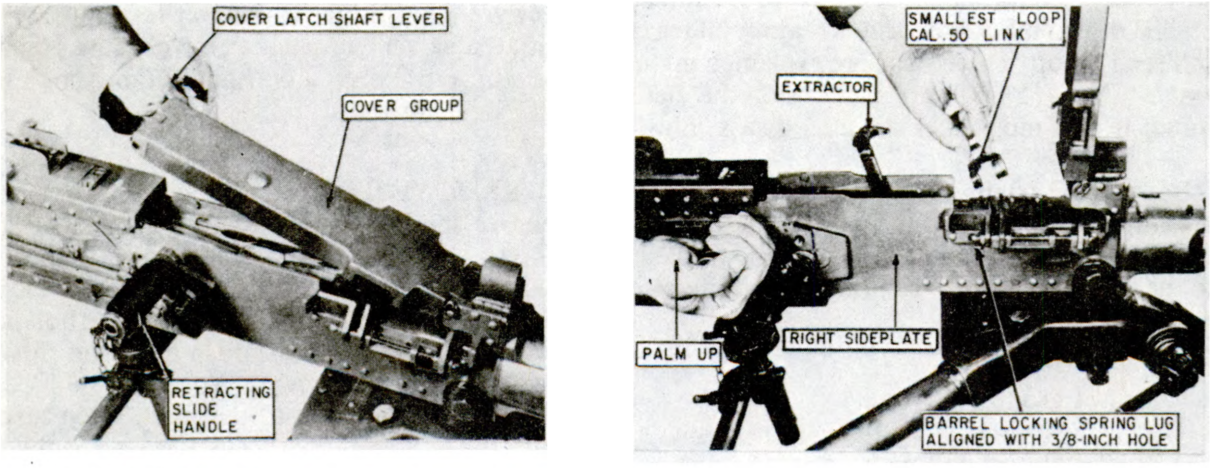
The second condition is that the bolt must be forward. If it is not, depress the bolt latch release. At the same time, use the retracting slide handle to ease the bolt forward.

When the bolt latch release is up and the bolt is forward, the backplate assembly can be removed. (See view B of figure 13-33.) Located below the buffer tube sleeve are the backplate latch and latch lock. Pull out on the latch lock and up on the latch as shown. Remove the backplate by lifting it straight up.

REMOVE DRIVING SPRING ROD ASSEMBLY.—The driving spring rod assembly consists of its inner and outer springs and a rod. The assembly is located next to the right sideplate inside the receiver. See figure 13-34.

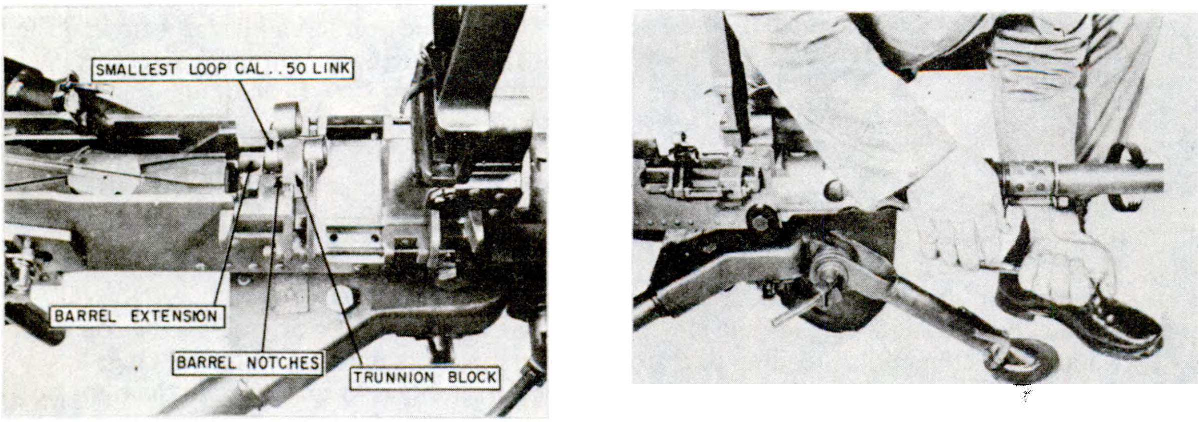
To remove the assembly, push in on the head of the driving spring rod. Push it to the left and remove the driving spring rod retaining pin from its seat in the right sideplate. Pull the complete assembly to the rear and out of the receiver.

Use caution when removing the driving spring rod assembly. There is a slight pressure on the springs when the bolt is forward. Never attempt



A-RAISING THE COVER GROUP.

B-ALIGNING THE LUG ON THE BARREL LOCKING SPRING WITH THE 3/8-INCH HOLE IN THE RECEIVER'S RIGHT SIDEPLATE.



C-USING THE SMALLEST LOOP OF A .50-CAL LINK TO KEEP THE BARREL LOCKING SPRING LUG ALIGNED WITH THE 3/8-INCH HOLE.

D-UNSCREWING THE BARREL GROUP FROM THE RECEIVER.

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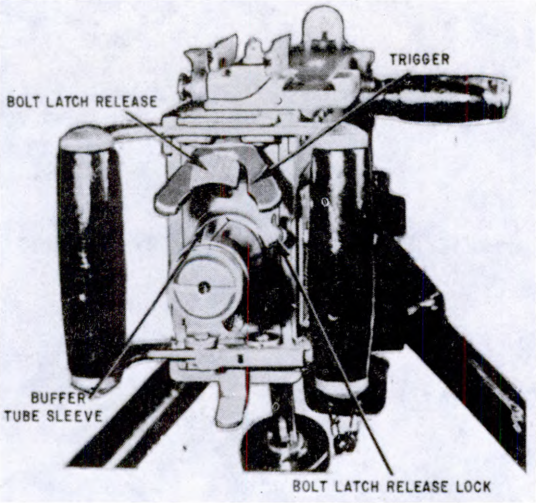
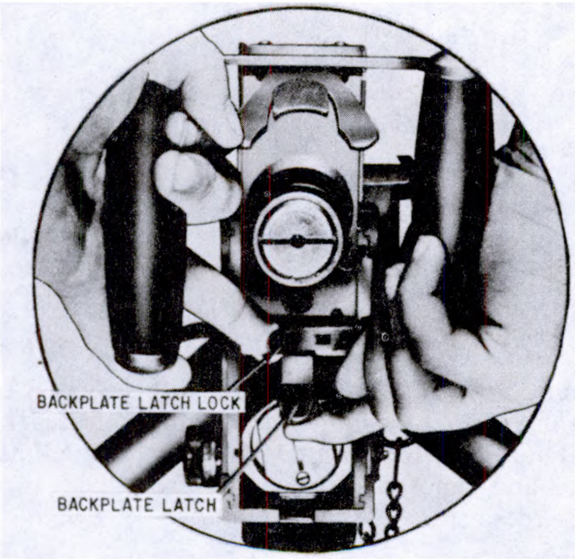
Figure 13-32.—Removing the barrel group.



A-BOLT LATCH RELEASE LOCK FREE OF THE BOLT LATCH RELEASE.



B-PULL OUT ON THE BACKPLATE LATCH LOCK AND UP ON THE BACKPLATE LATCH.

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Figure 13-33.—Removing the backplate assembly.

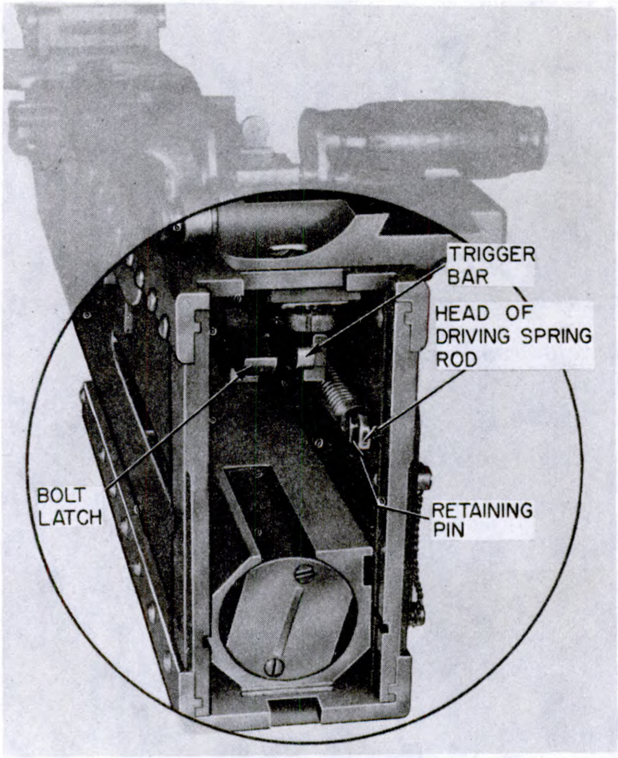

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Figure 13-34.—Removing the driving spring rod assembly.

to cock the gun while the backplate assembly is off and the driving spring rod assembly is installed. Cocking the gun will compress the spring group. If the retaining pin slips from its seat, the rod will come flying out! Anyone standing behind the gun will be injured.

REMOVE BOLT STUD.—To remove the bolt stud (a shoulder headless pin), grasp the retracting slide handle. Give it a quick jerk about halfway to the rear. That action frees the bolt group from the barrel extension group. Move the bolt rearward until the shoulder on the bolt stud aligns with a clearance hole. The hole is in the bolt slot on the right sideplate (figure 13-35). Removing the bolt stud frees the bolt group.

If the bolt is accidentally moved all the way to the rear, it will lock in place. If that occurs, raise the bolt latch. (Refer to figure 13-34.) Push the bolt forward to align the bolt stud with the clearance hole. Then proceed as before.

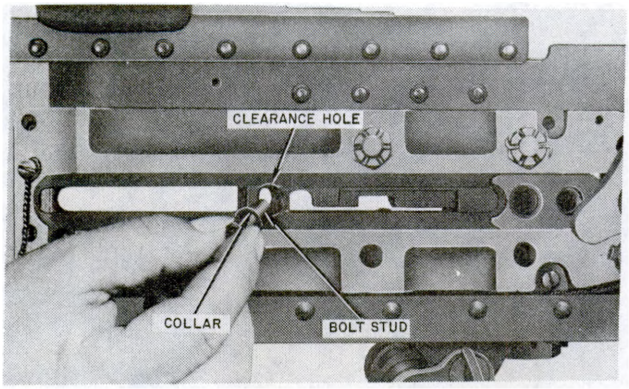

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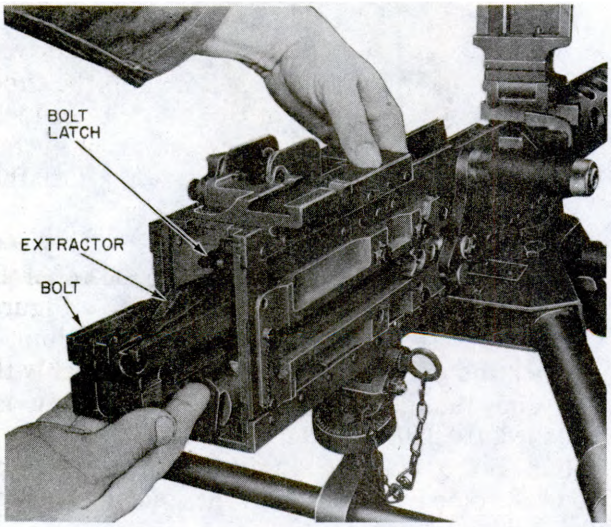
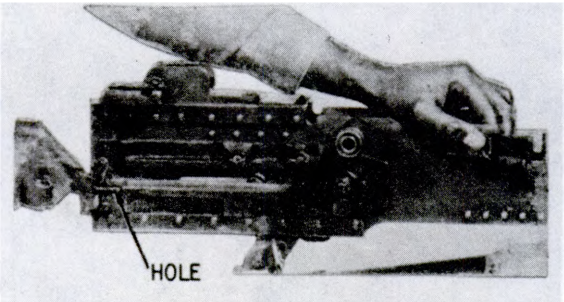
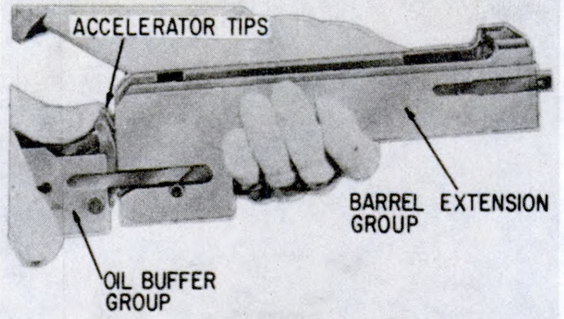
Figure 13-35.—Removing the bolt stud.



84.367
Figure 13-36.—Removing the bolt group.



A- UNLOCKING THE OIL BUFFER BODY'S SPRING LOCK.



B- SEPARATING THE OIL BUFFER GROUP AND THE BARREL EXTENSION GROUP.

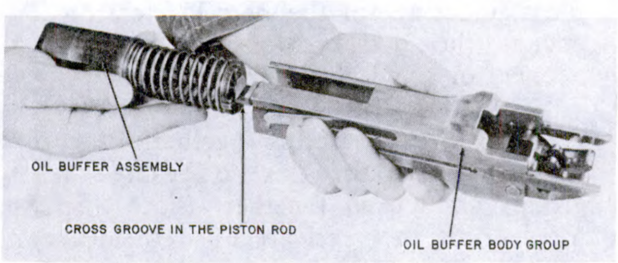
84.368
Figure 13-37.—Removing the oil buffer body and barrel extension groups.

REMOVE BOLT GROUP.—To remove the bolt group (bolt), refer to figure 13-36. After freeing the bolt, slide it from the rear of the receiver. Place the bolt down on its right side with the extractor arm up. That prevents the extractor from falling out of the bolt.

REMOVE OIL BUFFER BODY AND BARREL EXTENSION GROUPS.—These two groups are removed as a unit. To remove them, insert a pointed tool through a hole in the lower rear corner of the right sideplate. (See view A of figure 13-37.) Pushing in on the tool releases the oil buffer body's spring lock. At the same time, pull and remove the two groups from the rear of the receiver.

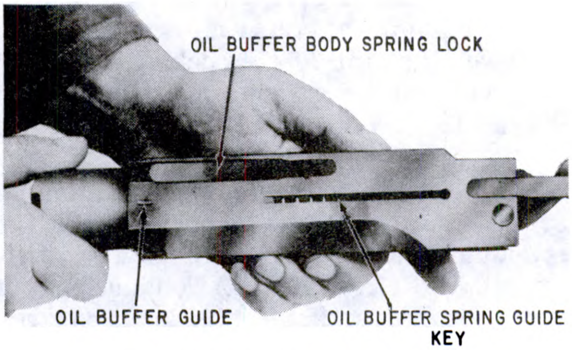
Now separate the oil buffer body group from the barrel extension group. Hold the unit as shown in view B of the figure. Push forward on the tips of the accelerator and pull the two groups apart.

REMOVE OIL BUFFER ASSEMBLY.—To remove the oil buffer assembly, hold the buffer

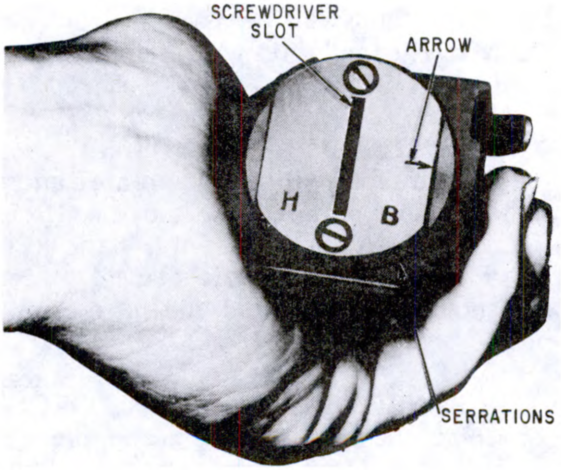


84.370

Figure 13-38.—Removing the oil buffer assembly.



A- SLIDING OIL BUFFER ASSEMBLY INTO OIL BUFFER BODY



B- ENSURE SCREWDRIVER SLOT IS VERTICAL AND ARROW POINTS TO THE RIGHT.

84.372

Figure 13-39.—Replacing the oil buffer assembly.

body as shown in figure 13-38. Pull the buffer assembly to the rear. That completes the general disassembly of the .50-cal BMG. Limited cleaning, maintenance, and major part/group replacement can be done now.

General Assembly

To reassemble the .50-cal BMG, replace the major component groups in reverse order. There are certain procedures (or "tricks," if you wish) to observe in doing the job correctly. General assembly procedures are explained in the following paragraphs.

REPLACE OIL BUFFER ASSEMBLY.—Slide the oil buffer assembly into the oil buffer body group. Ensure the spring guide key fits into the slot in the oil buffer body. (See view A of figure 13-39.)

Turn the oil buffer tube until the screwdriver slot is vertical (view B). The arrow on the tube must point to the right. The stud on the tube lock will now engage the serrations in the oil buffer tube. That keeps the tube from turning. Push the oil buffer assembly all the way forward.

REPLACE OIL BUFFER BODY AND BARREL EXTENSION GROUPS.—Figure 13-40 illustrates how these two groups are joined together. Align the breech lock depressors with

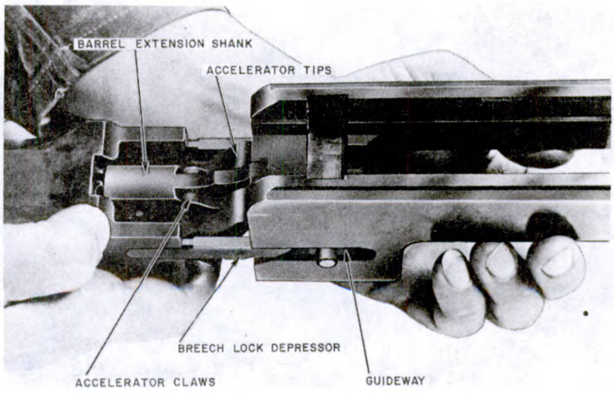


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Figure 13-40.—Joining the oil buffer body and barrel extension groups.

their guideways in the barrel extension. Also engage the barrel extension shank to the accelerator claws as shown.

Push the two groups together. Press down on the accelerator tips to ensure the two groups are locked together. Place them into the rear of the receiver. Push them forward until the oil buffer body spring lock (view A of figure 13-39) snaps in place. Properly locked in place, the oil buffer tube should protrude about 1-1/8 inch from the rear of the oil buffer body group.

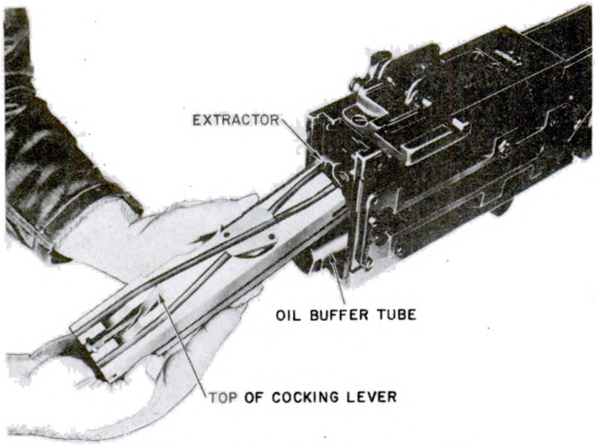
REPLACE BOLT GROUP.—Figure 13-41 illustrates how the bolt group is replaced into the receiver. The top of the cocking lever must be forward and the extractor must be down (flat). (Refer to view A.)

Push the bolt forward, maneuvering it so the front end clears the accelerator tips. That condition can be seen through the receiver's sideplate. (Refer to view B.) Continue pushing the bolt forward until the bolt latch engages the notches in the top of the bolt.

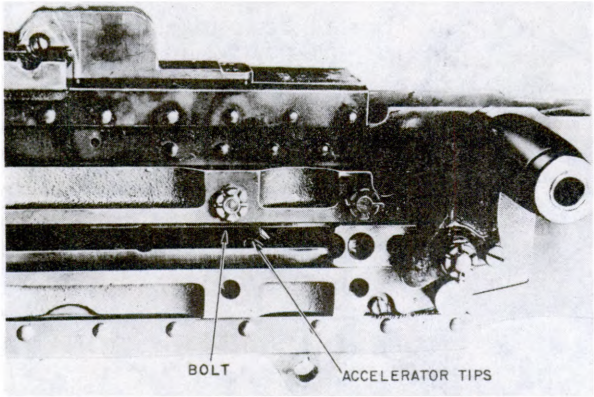
View C of the figure illustrates an optional procedure. The oil buffer body, barrel extension, and bolt groups can be assembled outside the receiver. Then, all three groups are inserted as a single unit.

REPLACE BOLT STUD.—The actions required to replace the bolt stud are almost the same as those required to remove it. (Refer to figure 13-35.) Align the stud hole in the bolt with the clearance hole in the right sideplate. Ensure the shoulder of the stud fits inside the sideplate.

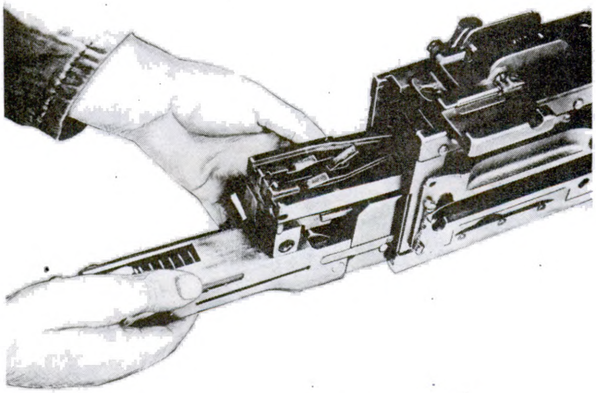
REPLACE DRIVING SPRING GROUP.—To replace the driving spring group, press up on the bolt latch. Move the bolt all the way forward by pushing on the bolt stud only. Place the end of the driving spring rod in its hole in the back of the bolt. Then, push forward on the driving spring groups and the oil buffer tube. Press in and push the head of the rod to the right. Insert the retaining pin in its seat in the right sideplate. (Refer to figure 13-34.)



A- PLACING BOLT INTO RECEIVER.



B- BOLT CLEARING ACCELERATOR TIPS.



C- REPLACING OIL BUFFER BODY, BARREL EXTENSION, AND BOLT GROUPS AS A UNIT.

84.375

Figure 13-41.—Replacing the bolt group.

REPLACE BACKPLATE ASSEMBLY.—To replace the backplate, hold its latch down and the trigger up. Position the backplate guides in their guideways. Hold the latch lock out and slide the backplate down until the latch snaps into place. (See figure 13-42.) Release the latch lock and tug up on the backplate assembly to ensure it is firmly seated.

REPLACE BARREL GROUP.—To replace the barrel group, pull the retracting slide handle to the rear. Do so until the lug on the barrel locking spring is visible through the 3/8-inch hole in the right sideplate. (Refer to figure 13-32.) Again, insert the smallest loop of a .50-cal link, or suitable spacer, between the trunnion block and barrel extension.

Screw the barrel all the way into the barrel extension. Then, and this is important, unscrew the barrel two notches. Remove the link and close the cover group. That completes the general assembly of the .50-cal BMG.

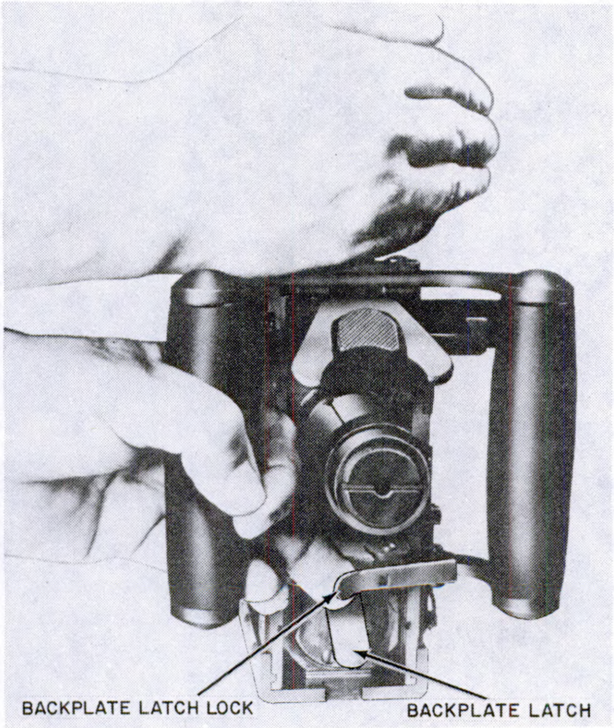


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Figure 13-42.—Replacing the backplate assembly.

Operating the .50-Cal BMG

The safest and best way to operate the .50-cal BMG is to follow established procedures. In doing so, you will prevent damage to the gun and injury to yourself and others. The basic operating procedures involve—

1. Loading
2. Half-loading
3. Full-loading
4. Unloading

Semiautomatic Operation

If single-shot firing is desired, the gun must be set for semiautomatic operation. To do so, the bolt latch release must be in the up position (or not locked down). (The bolt latch release can be seen in view A of figure 13-33.)

When the bolt latch release is up, the bolt latch assembly is depressed. In this position, the latch assembly can engage notches on top of the bolt when it (the bolt) is to the rear. Thus, when the bolt recoils after a round is fired, it remains locked to the rear.

Depressing the bolt latch release raises the latch assembly. The assembly disengages from the notches on top of the bolt. That allows the bolt to be driven forward into battery.

To fire the .50-cal BMG in semiautomatic, (1) depress the bolt latch release and (2) depress the trigger. These two actions must be done for each round fired.

Automatic Operation

If automatic firing is desired, the gun must be set for automatic operation. To do so, the bolt latch release must be depressed and locked down. That is done by turning the buffer tube sleeve. The bolt latch release lock is rotated to engage the bolt latch release, locking it down. (Refer to view A of figure 13-32 again.)

When the bolt latch release is locked down, the bolt latch assembly remains in its up position. Thus, when the bolt recoils, it is automatically free to return forward into battery.

To fire the .50-cal BMG in automatic, (1) lock the bolt latch release down and (2) depress the trigger. Short bursts are generally recommended, rather than sustained firings.

Loading Operation

The .50-cal BMG is loaded manually. It involves placing an ammunition belt into the gun's receiver. Ammunition for the .50-cal BMG comes prebelted and is shipped in a standard .50-cal ammunition box.

To load the gun, open and remove the lid on the ammunition box. Then open and raise the cover group on the gun (figure 13-43). Insert the

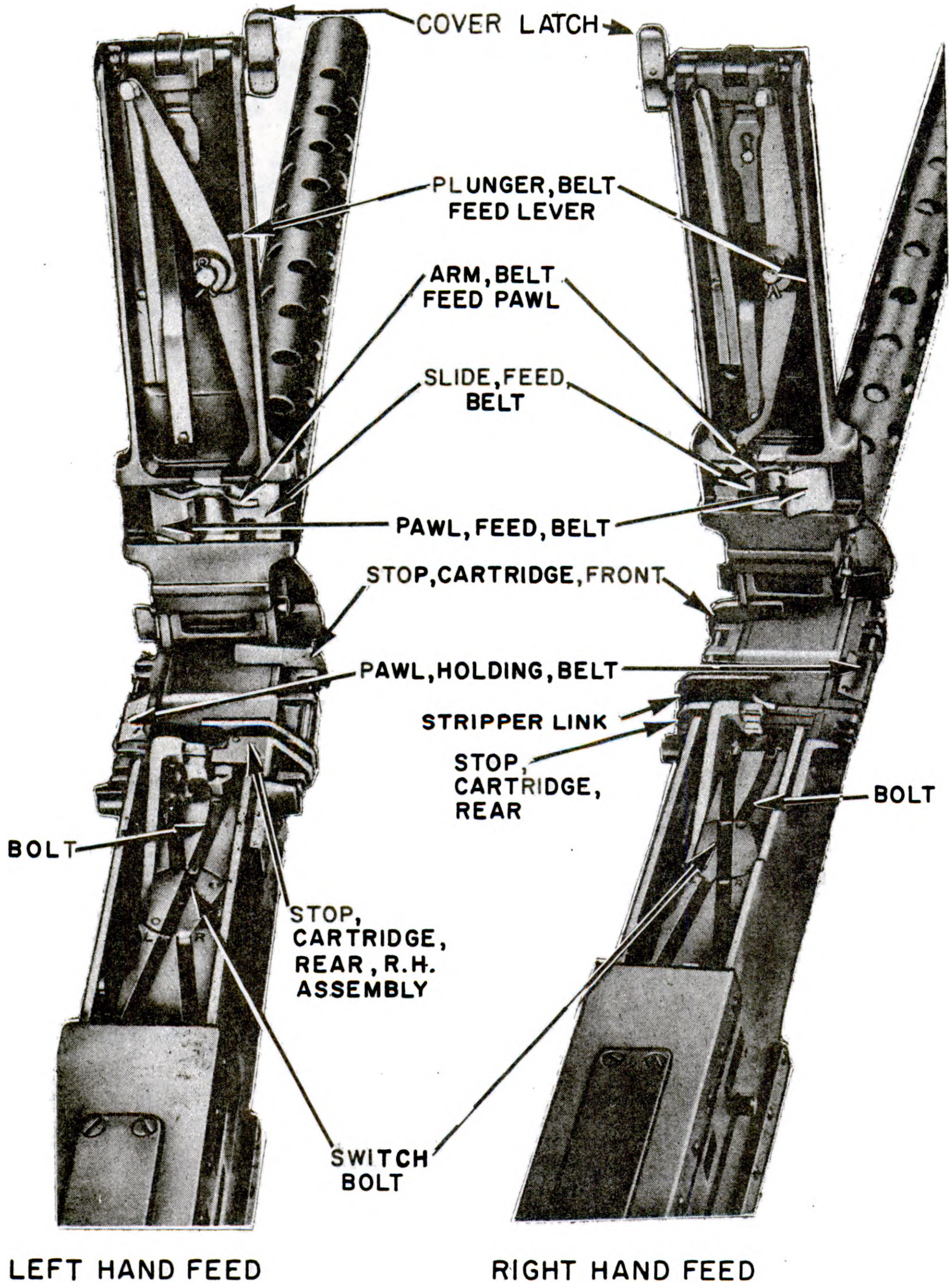

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Figure 13-43.—Receiver's feeding mechanism; parts set up for left-hand and right-hand feeding.

double-loop end of the ammunition belt into the receiver's feedway. Ensure the first cartridge is held by the belt-holding pawl. Close the cover group on the gun and make sure it is latched securely.

If two personnel are operating the .50-cal BMG, the assistant gunner loads the ammunition belt. The gunner performs the next two operations—half-loading and full-loading.

Half-Loading Operation

Half-loading is a term associated with the .50-cal BMG. It can be compared to feeding. Feeding was the first of eight steps in a cycle of operation. (Refer to figure 13-2.) It places a round in the receiver just to the rear of the receiver. Don't confuse loading the .50-cal BMG (described earlier) with half-loading. The two operations are different.

Half-loading the gun is done after the ammunition belt is installed and the cover group closed. To half-load the gun, the gunner grasps the retracting slide handle. It is pulled smartly to the rear and released. At this point, two things can occur. What happens depends on whether the gun is set for automatic or semiautomatic fire.

When the gun is set for automatic fire, the bolt latch release lock holds the bolt latch release down. When the retracting slide handle is released, it and the bolt will go forward. They are driven forward under pressure from the driving spring group. The gun is now half-loaded (in automatic).

When the gun is set for semiautomatic fire, the bolt latch release is up. When the retracting slide handle is released, it and the bolt will remain to the rear. To complete the half-load operation, the gunner must do two things. First, the retracting slide handle must be pushed all the way forward. Second, the bolt latch release must be depressed. That unlocks the bolt and it drives forward. The gun is now half-loaded (in semiautomatic).

Can the .50-cal BMG be fired now that it is half-loaded? The answer is no. Half-loading only places a round in the receiver, behind the barrel. The round must be chambered before it can be fired.

Full-Loading Operation

Full-loading a .50-cal BMG can be compared to chambering. Chambering was the second of eight steps in a cycle of operation. It places a new round in the gun's chamber.

To full-load the gun, you must repeat the half-loading sequence. Pull the retracting slide handle to the rear and release it. The weapon is now ready to fire.

Unloading Operation

To unload a .50-cal BMG, unlock the bolt release latch (if applicable) and open the cover group. Lift the ammunition belt out of the feedway. Pull the retracting slide handle to the rear and lock the bolt. Look and/or feel to make sure no ammunition is in the gun.

If the weapon is clear, lower the extractor. Release the bolt and ease the retracting slide handle forward. Then lower and secure the cover group. To complete unload operations, depress the trigger to uncock the firing mechanism.

Cycle of Operation

The first two steps of the eight-step cycle of operation have already been discussed. Initial feeding and chambering are accomplished during the manual half- and full-loading operations. After the first round is fired, feeding and chambering are done by the action of the gun.

The remaining steps in a .50-cal BMG's cycle of operation are summarized below.

1. Locking—The bolt is locked to the barrel and barrel extension.
2. Firing—The firing pin is released and driven forward to strike the cartridge's primer.
3. Unlocking—The bolt unlocks from the barrel and barrel extension.
4. Extracting—The empty cartridge case is pulled from the chamber.
5. Ejecting—The empty cartridge case is ejected from the receiver.
6. Cocking—The firing pin is withdrawn into its cocked position.

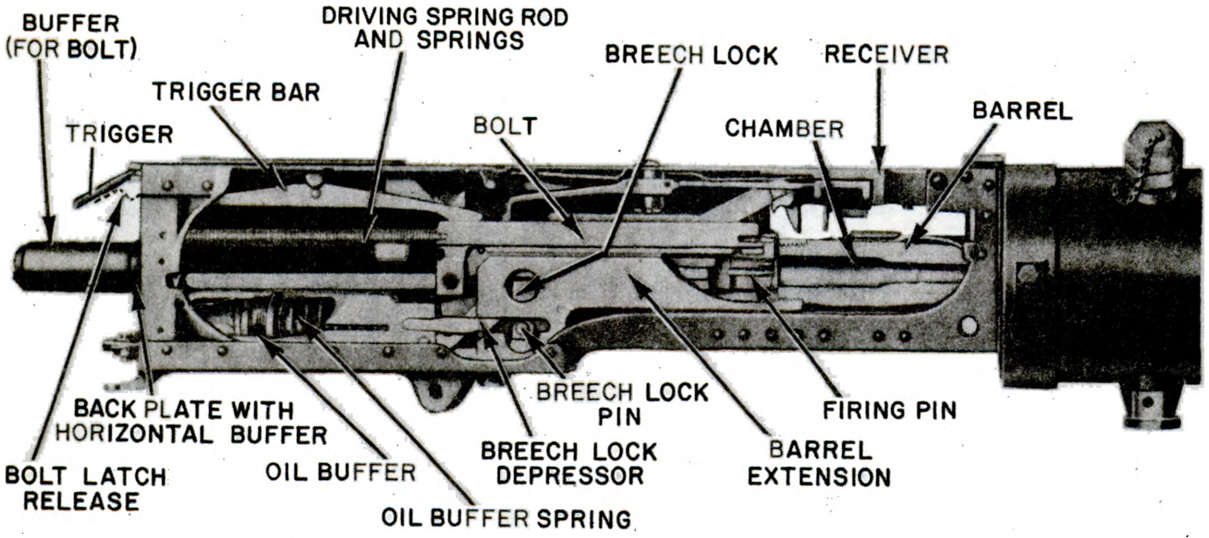

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Figure 13-44.—The .50-cal BMG receiver; cutaway view.

You can follow most of the gun's operating cycle by referring to figure 13-44. Assume the chamber is loaded, the gun is cocked, and the bolt latch is released.

The trigger is depressed. The trigger bar pivots and releases the cocked firing mechanism. The spring-loaded firing pin strikes the primer and the cartridge fires. Pressure from the expanding gases causes the gun's recoiling parts to start moving rearward.

During the first three-fourths of an inch of rearward travel, the recoiling parts remain locked together. However, the breech lock depressors are acting on the breech lock pin. That action forces the breech lock down and out of the bolt. As a result, at the end of the first three-fourths of an inch of recoil, the bolt is unlocked. It is free to continue recoiling independent of the barrel and barrel extension.

The barrel extension hits the accelerator. It, in turn, hits the bolt and accelerates it (the bolt) to the rear. The barrel and barrel extension recoil another three-eighths of an inch (1-1/8 inch total travel). They are stopped by the oil buffer assembly.

Meanwhile, the bolt recoils an additional 6-3/8 inches to the rear (7-1/8 inches total travel). During this movement, the driving spring group is compressed. The bolt is stopped by the bolt buffer mechanism. The fired cartridge is extracted and the firing mechanism is cocked.

Counterrecoil forces the bolt forward. The empty cartridge case is ejected. The bolt locks to the barrel extension and both move forward into battery. Feeding and chambering have taken place and the gun is ready to fire. The cycle begins when the firing pin is released to set off the next cartridge.

Headspace and Timing Adjustments

By now, you should realize that the .50-cal BMG is a complex working machine. The care and maintenance given this gun are critical for safe and continued operation. In addition to normal lubrication and cleaning practices, checking and adjusting the headspace and timing of the weapon are mandatory.

HEADSPACE ADJUSTMENT.—Headspace is the distance between the face of the bolt and

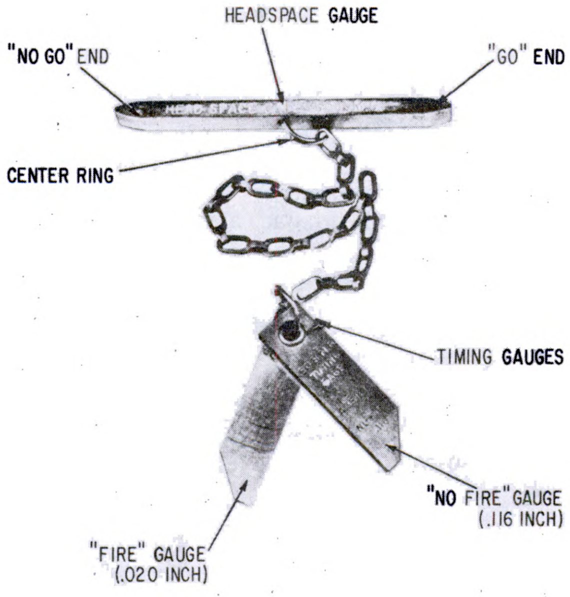

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Figure 13-45.—Headspace and timing gauge set.

the base of a seated cartridge case. The distance is correct when the following conditions are met.

1. The recoiling groups are fully forward.
2. There is no independent rearward movement between the bolt, barrel, and barrel extension.

Improper headspace adjustment can cause a lot of problems. The gun will not operate properly and, frequently, damage will result. Also, personnel are subject to injury.

Headspace must be checked and set before firing the gun. Other instances include:

1. When the gun is assembled.
2. When the barrel or any major group or assembly within the receiver is replaced.
3. When there is doubt that correct headspace is set.

A special tool is used to check and set the headspace distance. It is called the "headspace gauge" and is part of the headspace and timing gauge set (figure 13-45). The tool should be kept with the gun at all times. For now, we're only interested in the GO/NO GO headspace gauge. The following steps explain how to check and set the headspace adjustment.

1. With the cover group closed, cock the gun. Do so by pulling the retracting slide handle all the way to the rear.
2. Depress the bolt latch release and slowly ease the retracting slide handle and bolt all the way forward.
3. Raise the cover group. Pull back on the retracting slide handle slightly. Move the bolt not more than one-sixteenth of an inch to the rear. That prevents the driving spring group and the weight of the parts from giving a false reading. Raise the extractor.
4. Insert the GO end of the headspace gauge into the T-slot. The T-slot is between the face of the bolt and the rear of the barrel. (Refer to figure 13-46.) The GO end of the gauge should enter the T-slot freely up to the center ring of the gauge. Remove the gauge and try to insert the NO GO

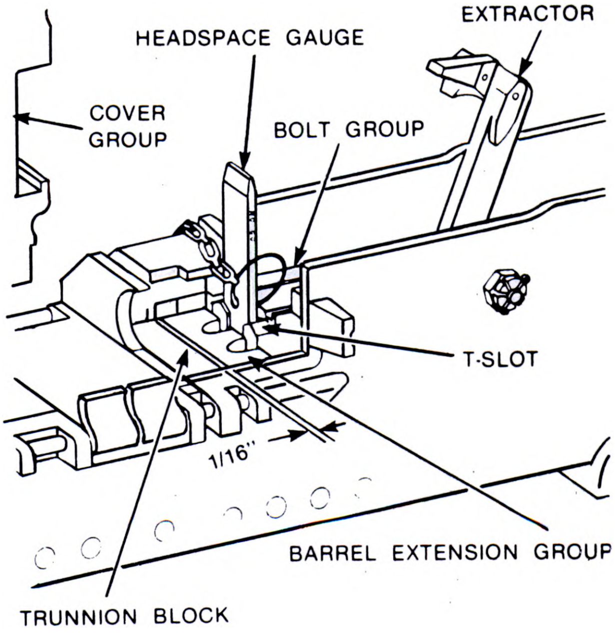

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Figure 13-46.—Checking the headspace with the GO end of the headspace gauge.

end into the T-slot. If the NO GO end will not enter the slot, headspace distance is correct.

Headspace Too Tight.—If the headspace is too tight, the GO end of the gauge cannot enter the T-slot freely. To correct this situation, take the following steps.

1. Pull back on the retracting slide handle. Do so until the lug on the barrel locking spring is visible through the 3/8-inch hole in the right sideplate. (Refer to figure 13-32.)

2. Unscrew the barrel one notch (click).

3. Ease the retracting slide handle and bolt fully forward.

4. Retract the bolt slightly, not exceeding one-sixteenth of an inch. (Refer to figure 13-46.) Recheck the headspace adjustment as before.

If necessary, repeat this procedure to obtain the proper adjustment. Be sure to unscrew the barrel only one notch (click) each time. If the adjustment cannot be made within one to five (maximum) notches (clicks), notify the maintenance supervisor.

Headspace Too Loose.—If the headspace is too loose, the NO GO end of the gauge will enter the T-slot freely. The adjustment procedures for this situation are the same as those just described. However, screw the barrel in one notch (click) at a time for each adjustment attempt.

TIMING ADJUSTMENT.—Timing of the weapon is as critical as headspace adjustment. Timing ensures that firing takes place when the recoiling parts are between .020 and .116 inch out of battery. That prevents contact between the front end of the barrel extension and the trunnion block. Timing is correct when the following conditions are met.

1. The recoiling parts are locked together.
2. Firing takes place just before the recoiling parts are in battery (fully forward).
3. The gun fires on the FIRE gauge and does not fire on the NO FIRE gauge.

The gun's timing is checked with the FIRE (.020 inch) and NO FIRE (.116 inch) gauges seen in figure 13-45. Timing must be checked and/or set (1) each time headspace is adjusted and (2) whenever the timing is questionable. The following steps explain how to check and set the timing adjustment.

1. Ensure the headspace adjustment is correct. If not, correct it before checking the timing.
2. Ensure the firing pin is cocked and the recoiling parts are forward in battery position.
3. Raise the extractor.
4. Retract the recoiling parts enough to insert the FIRE (.020 inch) gauge. Place it between the barrel extension and trunnion block (figure 13-47).
5. Allow the barrel extension to close on the gauge slowly.
6. Depress the trigger. The firing pin should release. Releasing indicates that the timing is correct (or not late).

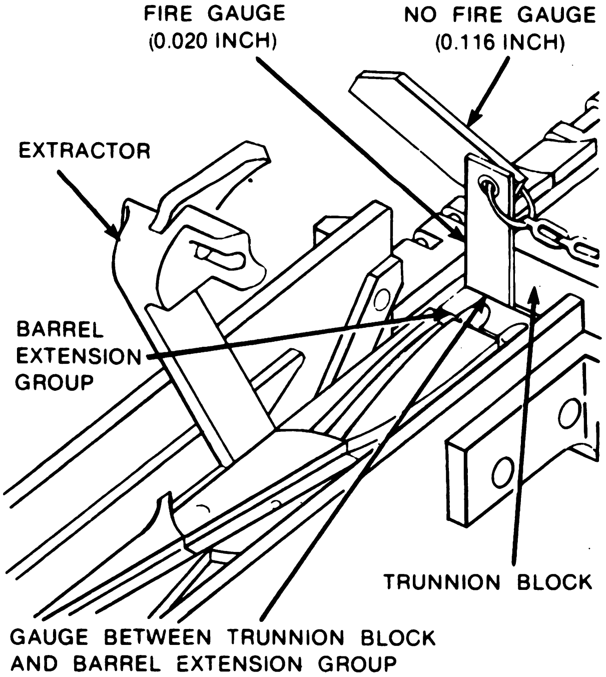

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Figure 13-47.—Checking the timing with the FIRE gauge installed.

7. Retract the recoiling parts enough to remove the FIRE gauge. Cock the gun and allow the recoiling parts to go forward into battery.

8. Retract the recoiling parts enough to insert the NO FIRE (.116 inch) gauge. Place it in the same location, between the barrel extension and the trunnion block (figure 13-48).

9. Depress the trigger. The firing pin should not release. Its failure to release indicates that the timing is correct (or not early).

Late Timing Adjustment.—If the gun's timing is late, the firing pin will not release with the FIRE gauge installed. (Refer to step 6 above.) To correct this situation, perform the following steps.

1. Retract the recoiling parts enough to remove the FIRE gauge. Allow them to return forward into battery.

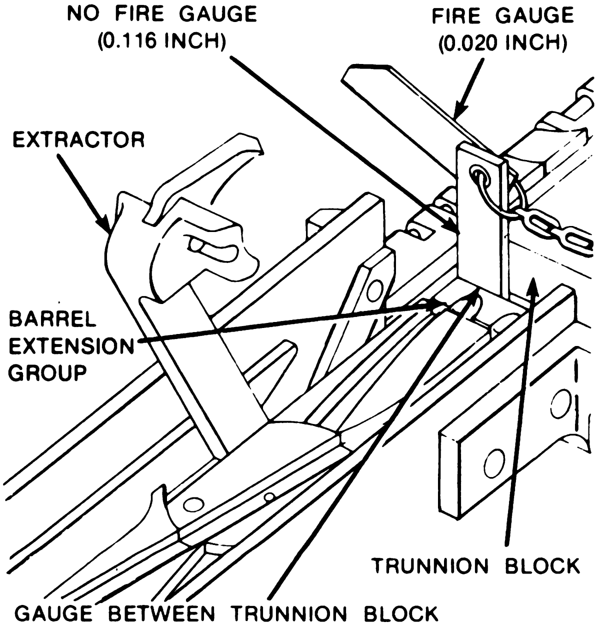
NO FIRE GAUGE (0.116 INCH)
FIRE GAUGE (0.020 INCH)
EXTRACTOR
BARREL EXTENSION GROUP
TRUNNION BLOCK
GAUGE BETWEEN TRUNNION BLOCK AND BARREL EXTENSION GROUP

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Figure 13-48.—Checking the timing with the NO FIRE gauge installed.

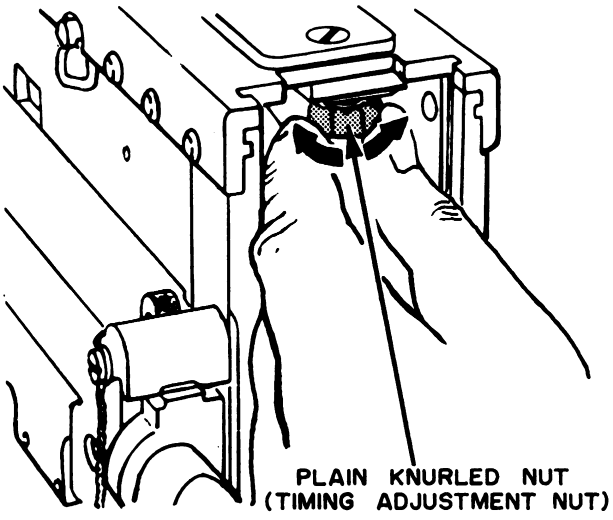

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Figure 13-49.—Turning the trigger bar adjusting nut: turn to the right to correct for late timing; turn to the left to correct for early timing.

2. Remove the backplate assembly. (Refer to figure 13-33.)

3. Locate and turn the trigger bar adjusting nut one notch to the right (figure 13-49).

4. Reinstall the backplate assembly. (Refer to figure 13-42.)

5. Retract the recoiling parts enough to insert the FIRE gauge again. Allow the barrel extension to close on the gauge slowly.

6. Depress the trigger. The firing pin should release.

If necessary, repeat the procedure until the firing pin releases with the FIRE gauge installed.

Early Timing Adjustment.—If the gun's timing is early, the firing pin will release with the NO FIRE gauge installed. The adjustment procedures for this situation are the same as those described above. However, turn the trigger bar adjusting nut one notch to the left. Reinstall the NO FIRE gauge and depress the trigger. The firing pin should not release. Repeat the procedure as necessary.

The importance of obtaining the correct headspace and timing adjustments on the .50-cal BMG cannot be stressed enough. The weapon's field manual (FM23-65) and appropriate MRCs describe the required procedures in detail. Consult those references to make these adjustments. Do them carefully and deliberately.

THE 7.62-MM M60 MACHINE GUN

The M60 machine gun (figure 13-50) is an air-cooled, belt-fed, gas-operated automatic weapon.

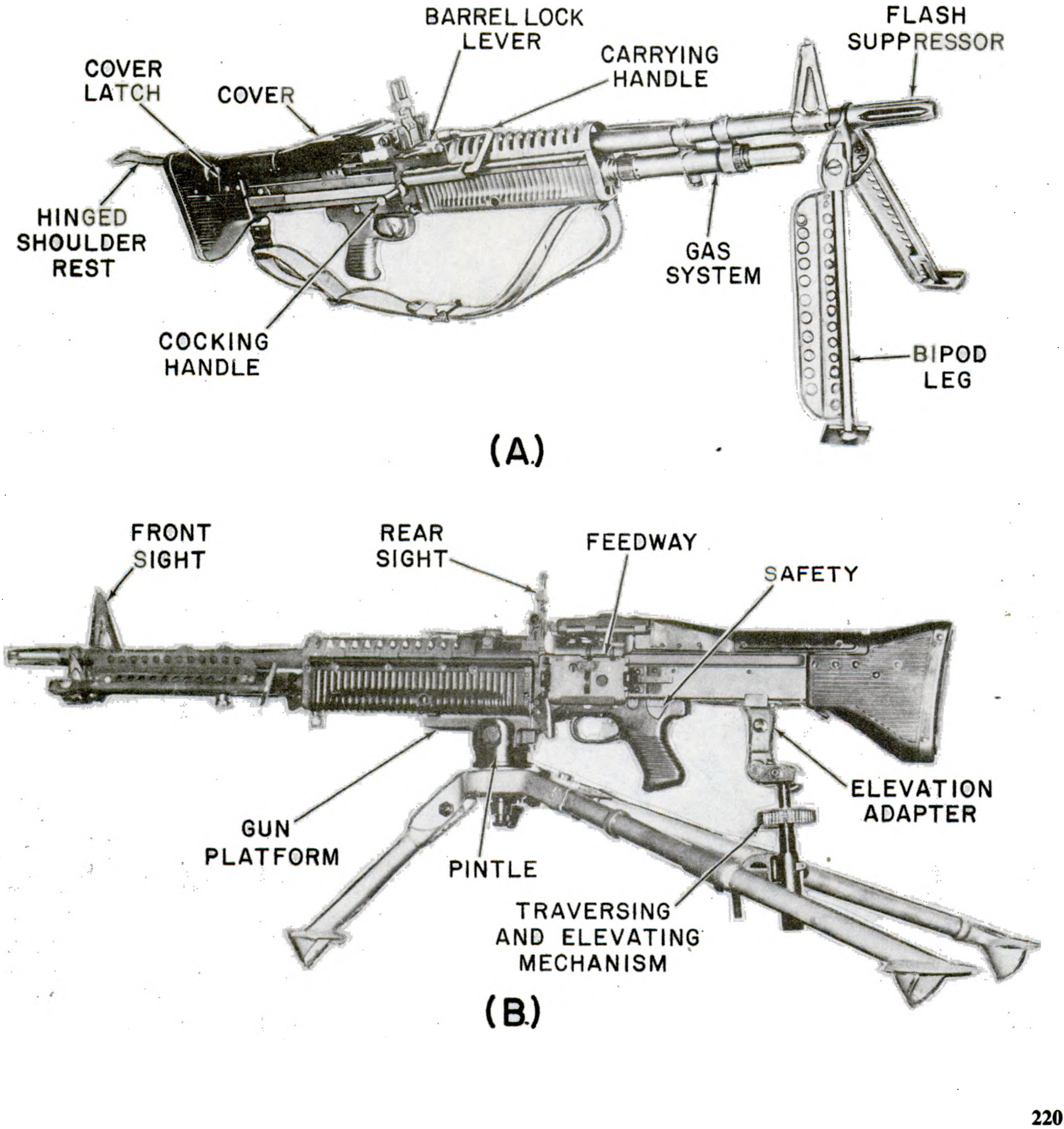

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Figure 13-50.—The M60 machine gun: A. Bipod mounted; B. Tripod mounted.

The machine gun was originally developed for use by ground troops. It is currently used on many types and classes of ships, river patrol craft, and combat helicopters.

Essential features of the M60 are as follows:

Length	43.5 in.
Weight	23 lb.
Maximum range	3,725 meters
Maximum effective range	1,100 meters
Ammunition	7.62-mm ball tracer, armor-piercing, incendiary, and dummy
Rates of fire:	
Sustained	100 rounds per minute (Change barrel every 10 minutes)
Rapid	200 rounds per minute (Change barrel every 2 minutes)
Cyclic	550 rounds per minute (Change barrel every minute)

General Description

The M60 has a front sight permanently affixed to the barrel. The rear sight is mounted on a spring-type dovetail base (figure 13-51) and can be folded forward when the gun is to be moved. The range plate on the sight is marked for each 100 meters, from 300 meters to the maximum effective range of 1,100 meters. Range changes may be made by using either the slide release or the elevating knob. The slide release is used for making major changes in elevation. The elevating knob is used for fine adjustments, such as during zeroing. Four clicks on the elevating knob equal a 1-mil change of elevation. The sight is adjustable for windage 5 mils right and left of zero. The windage knob is located on the left side of the sight. One click on the windage knob equals a 1-mil change of deflection.

NOTE: One mil equals 1 inch at 1,000 inches, 1 yard at 1,000 yards, 1 meter at 1,000 meters, etc.

A safety lever is located on the left side of the trigger housing. It has an S (SAFE) and an F (FIRE) position. On SAFE, the bolt cannot be pulled to the rear nor released to go forward. The cocking handle or lever, on the right side of the gun, is used to pull the bolt to the rear. It must be returned manually to its forward position each time the bolt is pulled to the rear.

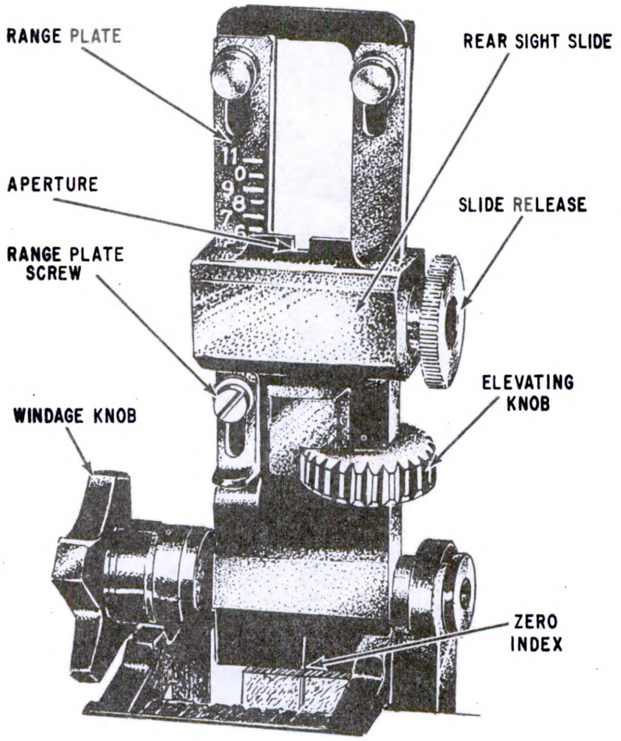

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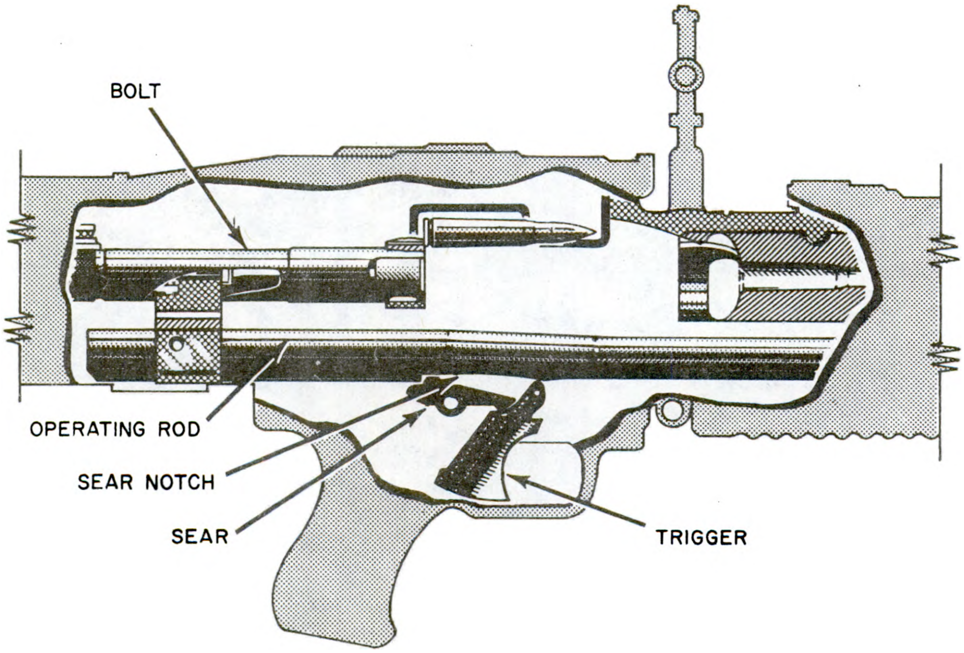
Figure 13-51.—Rear sight.

Operation of the M60 Machine Gun

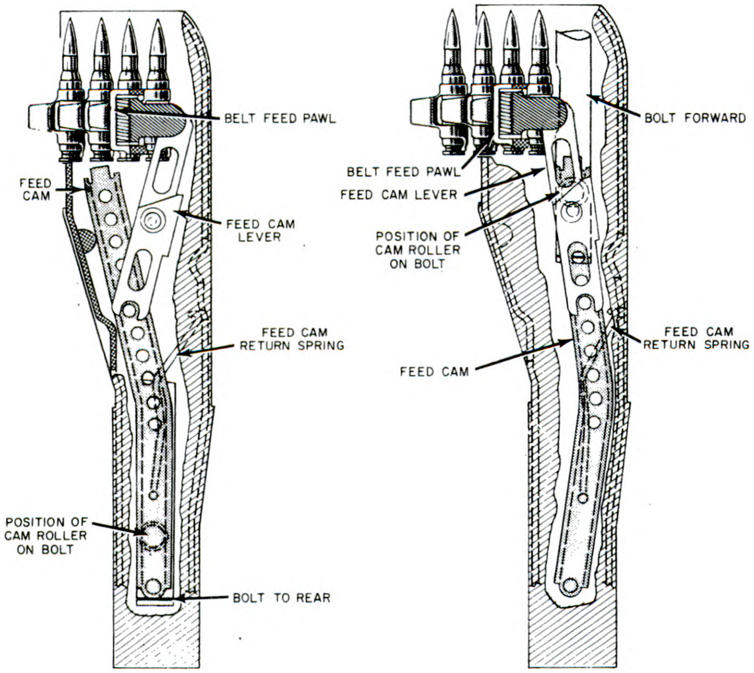
The M60 machine gun is designed to function automatically as long as ammunition is fed into the gun and the trigger is held to the rear. Each time a round is fired, the parts of the weapon function in a certain sequence. Many of the actions occur simultaneously. They are only separated here for training purposes. For ease of of understanding, the complete sequence or cycle of operation is discussed in the following eight steps:

1. Feeding: A round is positioned in the feed tray groove.
2. Chambering: A round is stripped from the belt and placed in the chamber.



220.52.1

Figure 13-52.—Sear disengaging from sear notch.



220.54

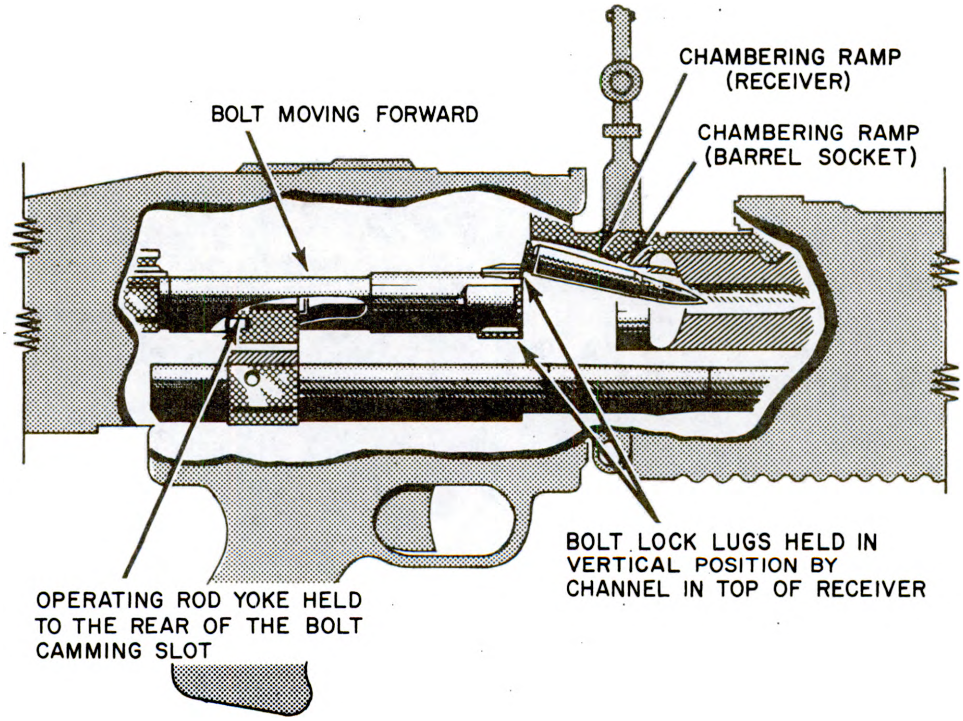
Figure 13-53.—Feeding.

3. Locking: The bolt is locked inside the barrel socket.
4. Firing: The firing pin strikes and detonates the primer of the cartridge.
5. Unlocking: The bolt is unlocked from the barrel socket.
6. Extracting: The empty case is pulled from the chamber.
7. Ejecting: The empty cartridge case is thrown from the receiver.
8. Cocking: The sear engages the sear notch.

FEEDING.—The cycle starts by putting a round in the feed tray groove. When the trigger is squeezed, the rear of the sear is lowered and disengaged from the sear notch (figure 13-52). This allows the operating rod and bolt to be driven forward by the expansion of the operating rod spring. Now that the gun is functioning, the steps of the cycle can be traced.

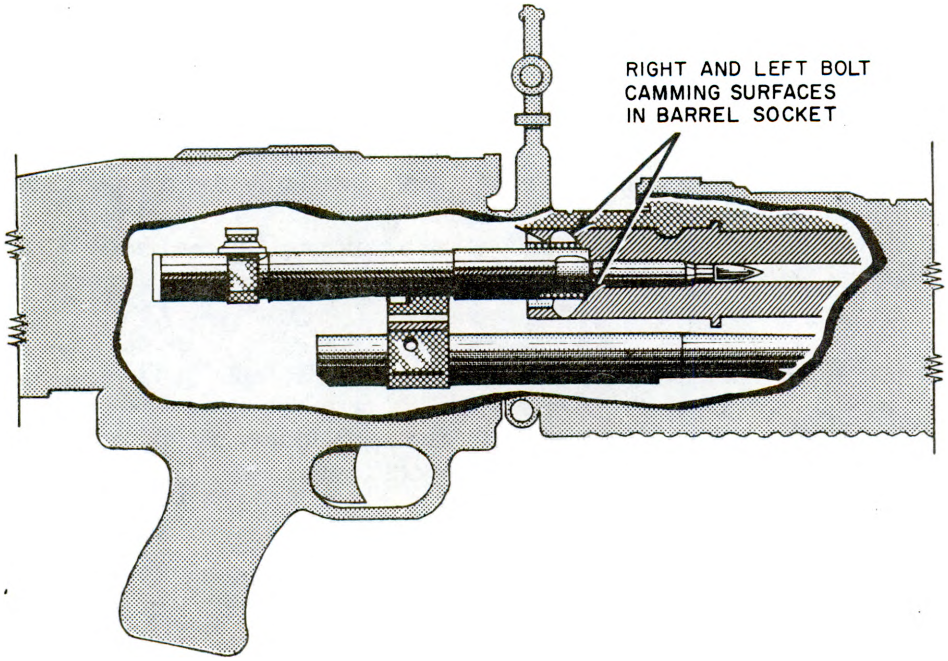
As the bolt begins its forward movement, the feed cam is forced to the right (figure 13-53). This causes the feed cam lever to pivot in the opposite direction. The feed cam lever forces the feed pawl over the next round in the belt. The next round is ready to be placed into the feed tray groove when the rearward action occurs again. After the weapon is fired, the bolt moves to the rear. The cam roller on the top of the bolt forces the feed cam to the left. The feed cam lever is forced to pivot, moving the feed pawl to the right again. This places a round in the feed tray groove.

CHAMBERING.—As the bolt travels forward, the upper locking lug engages the rim of the cartridge. Pressure from the front and rear cartridge guides holds the round so that positive contact is made with the upper locking lug of the bolt. The front cartridge guide prevents the link's forward motion as the round is stripped from the belt. The upper locking lug carries the round forward. The chambering ramp causes the nose of the cartridge to be cammed downward into the chamber (figure 13-54). When the round is fully


CHAMBERING RAMP (RECEIVER)
BOLT MOVING FORWARD
CHAMBERING RAMP (BARREL SOCKET)
BOLT LOCK LUGS HELD IN VERTICAL POSITION BY CHANNEL IN TOP OF RECEIVER
OPERATING ROD YOKE HELD TO THE REAR OF THE BOLT CAMMING SLOT

220.55

Figure 13-54.—Chambering.



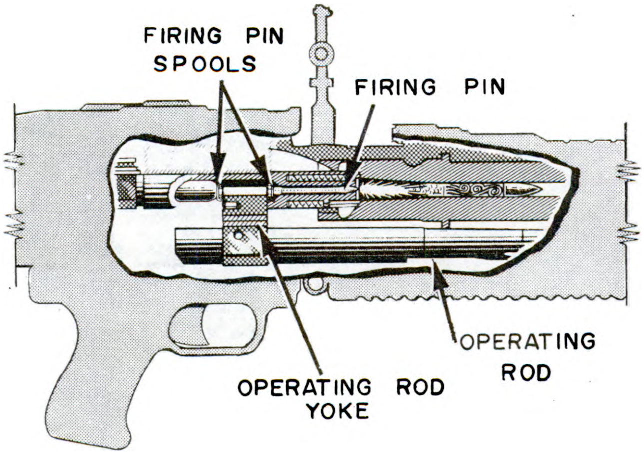
220.56

Figure 13-55.—Weapon locked and ready to fire.

seated in the chamber, the extractor snaps over the rim of the cartridge and the ejector (on the face of the bolt) is depressed.

LOCKING.—As the round is chambered, the bolt enters the barrel socket. The upper and lower locking lugs contact the bolt camming surfaces inside the barrel socket. This starts the rotation of the bolt clockwise. As the operating rod continues forward, the operating rod yoke acts against the bolt camming slot. The bolt is made to complete its one-quarter turn clockwise rotation (figure 13-55). Locking is then complete.

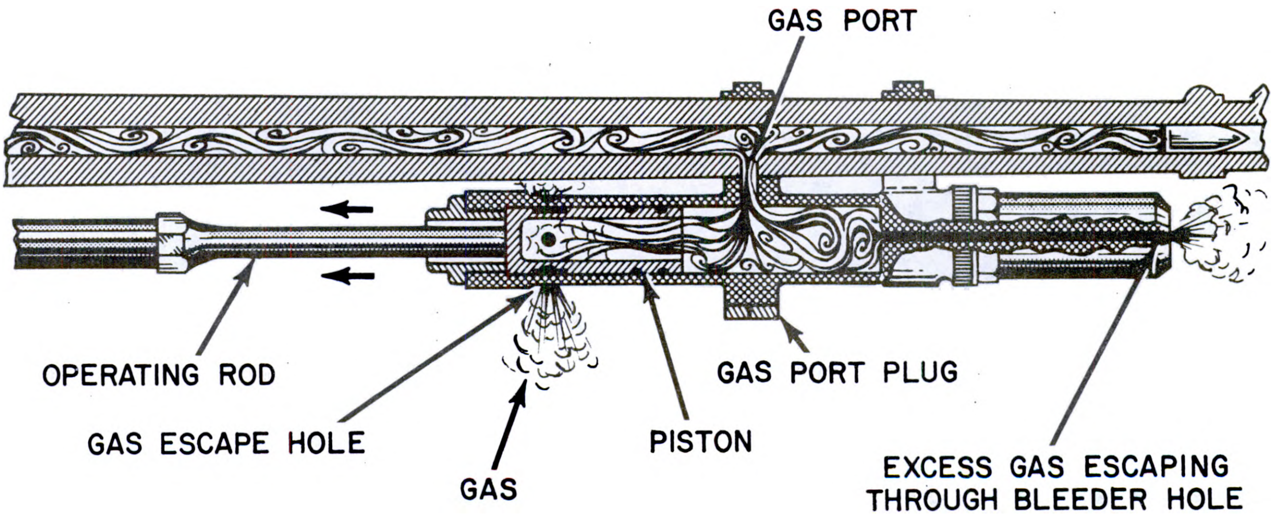
FIRING.—After the bolt reaches its fully forward and locked position, the operating rod (independent of the bolt) continues to go forward for a short distance. The yoke, engaged between the firing pin spools, carries the firing pin forward. The striker of the firing pin protrudes through the aperture in the face of the bolt. It strikes the primer of the cartridge and detonates it. This action is depicted in figure 13-56.



220.57

Figure 13-56.—Firing.

UNLOCKING.—After the cartridge is ignited and the projectile passes the gas port, part of the expanding gases enter the gas cylinder. The rapidly expanding gases act on the hollow gas piston (figure 13-57) and force it to the rear. The



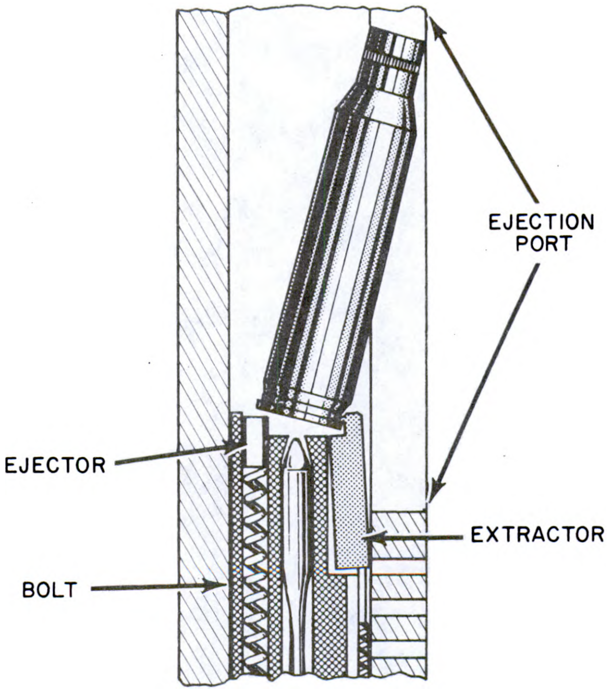
220.58

Figure 13-57.—Unlocking action of the expanding gases.

operating rod, being in contact with the piston, is also pushed to the rear. As the operating rod moves rearward, the operating rod yoke acts against the bolt camming slot. This causes the bolt to begin its counterclockwise rotation. The upper and lower locking lugs of the bolt contact the bolt camming surfaces inside the barrel socket. They cause the bolt to complete its one-quarter turn rotation (counterclockwise) and unlock from the barrel socket. Unlocking begins as the yoke of the operating rod contacts the curve of the bolt camming slot. Unlocking ends as the bolt clears the end of the barrel socket.

EXTRACTING AND EJECTING.—While unlocking is going on, extraction is beginning. The rotation of the bolt (in unlocking) loosens the cartridge case in the chamber. As the operating rod and bolt continue to the rear, the extractor (gripping the rim of the cartridge) pulls the cartridge case from the chamber. As the case is withdrawn from the chamber, the ejector spring expands. The ejector presses on the base of the cartridge case. It forces the front of the spent case against the right side of the receiver. See figure 13-58.

As the bolt continues to the rear, the ejector pushes against the base (left side) of the cartridge



220.59

Figure 13-58.—Extracting and ejecting.

case while the extractor grips the right side of the case. These actions cause the cartridge case to spin from the gun as the case reaches the ejection port. The empty link is forced out of the link ejection port as the rearward movement of the bolt causes the next round to be positioned in the feed tray groove.

COCKING.—As the expanding gases force the gas piston to the rear, the operating rod is initially moved independently of the bolt. The yoke of the operating rod acts against the rear firing pin spool. It withdraws the firing pin from the primer of the spent cartridge case. The action of the operating rod yoke continuing to the rear against the rear firing pin spool fully compresses the firing pin spring.

As long as the trigger is held, the weapon will continue to complete the first seven steps of functioning automatically. When the trigger is released, the sear again engages the sear notch. The cycles of operation are stopped and the weapon is cocked.

Disassembly of the M60 Machine Gun

Two types of disassembly procedures may be performed on the M60 machine gun—general and detailed. General disassembly procedures involve the removal of most of the major groups and assemblies of the weapon. The detailed procedures consist of removing the components of the major groups. Because the detailed procedures are complex, only the general disassembly procedures are discussed.

The M60 machine gun can be disassembled into six major groups without the use of force or special tools. These groups are shown in figure 13-59. With the exception of the barrel group, all disassembly steps can be accomplished with a driftpin or a similar pointed object.

General disassembly begins with the bolt forward, the cover closed, and the safety on SAFE. Before you disassemble the weapon, thoroughly inspect it to ensure it is unloaded. As you disassemble the weapon, place the parts (in

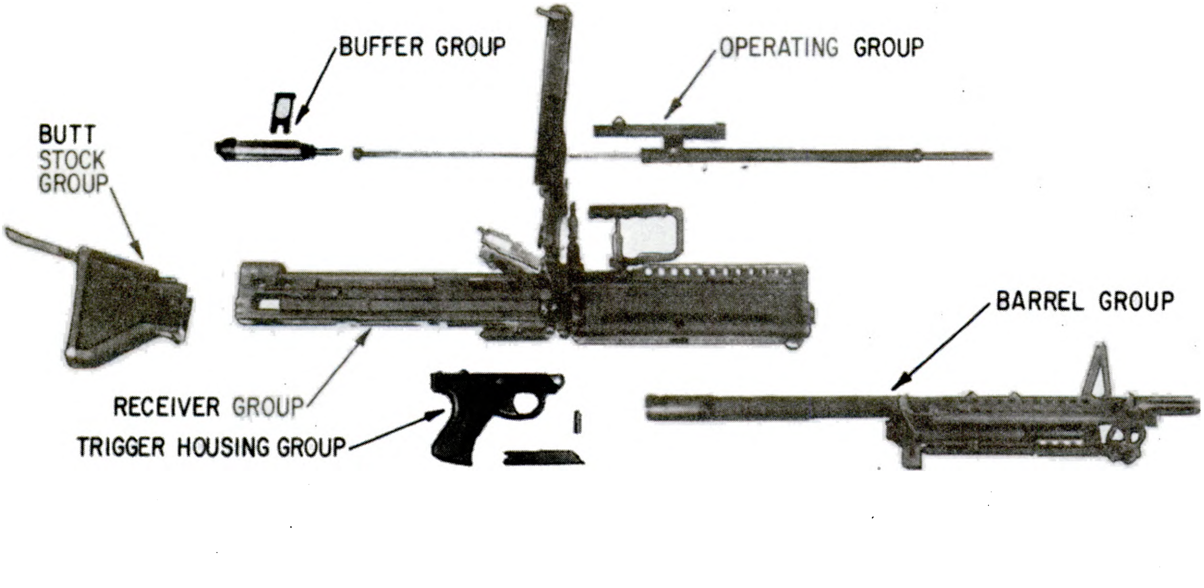


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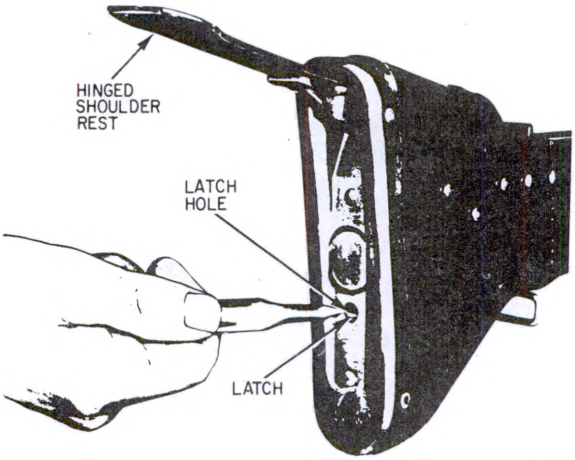
Figure 13-59.—Six major groups of the M60 machine gun.



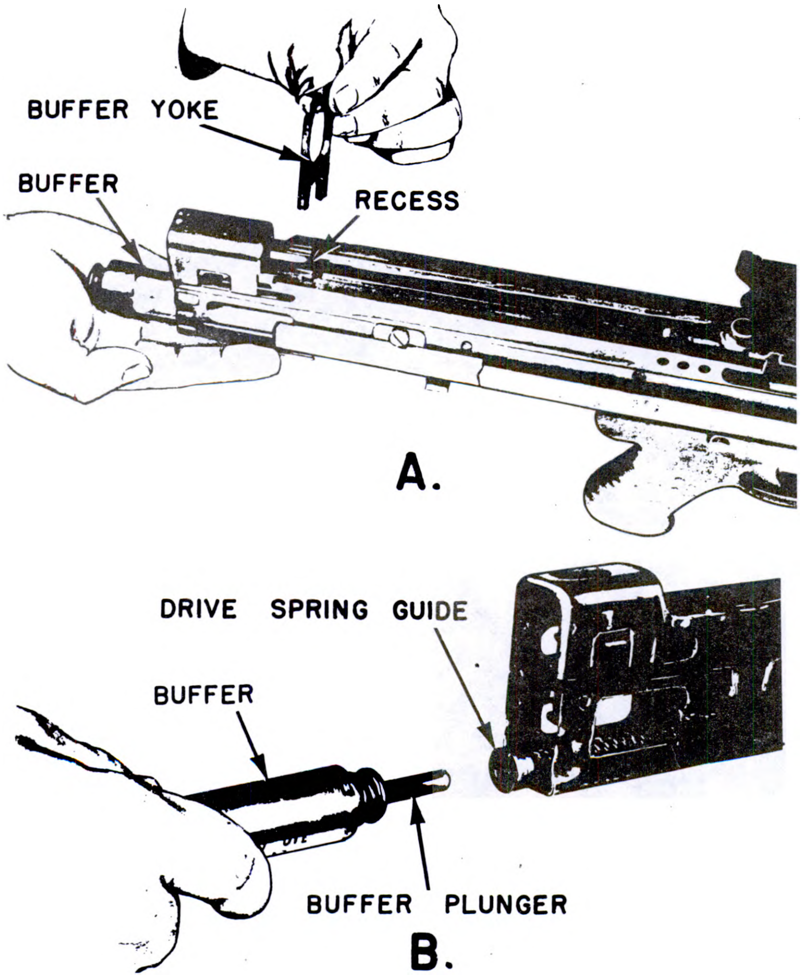
220.61

Figure 13-60.—Releasing the stock latch.

the order in which they are removed) on a clean, flat surface. This reduces the possibility of losing anything and aids in assembling the gun.

REMOVING THE STOCK GROUP.—To remove the stock group, raise the hinged shoulder rest. Insert the nose of a driftpin into the latch hole as shown in figure 13-60. With the latch depressed, remove the stock by pulling it directly to the rear.

REMOVING THE BUFFER GROUP.—The buffer group consists of the buffer yoke and the buffer. To disassemble this group, hold the palm of your hand against the exposed buffer and press in lightly. Remove the buffer yoke from the top of the receiver as illustrated in view A of figure 13-61. Withdraw the buffer slowly. Carefully,



220.62

Figure 13-61.—Removing the buffer group.

allow the drive spring to expand until the end of the drive spring guide is exposed at the rear of the receiver. Pull the buffer plunger from the drive spring guide. See view B of figure 13-61.

REMOVING THE OPERATING GROUP.—The operating group consists of the operating rod, bolt drive spring, and drive spring guide. To remove this group, pull the drive spring guide and spring (seen in figure 13-61) from the receiver and separate them. With one hand, grasp the pistol grip and pull the cocking handle to the rear. Do so until the bolt is separated from the barrel socket. Continue to pull the operating rod and bolt to the rear by pulling the actuating cam roller as shown in view A of figure 13-62.

Pull the operating rod and bolt until they are exposed about 4 inches to the rear of the receiver. Then grasp them securely to prevent the bolt from rotating. Remove them from the receiver as shown in view B of figure 13-62. Relax your grip and allow the bolt to rotate slowly. Do not separate the bolt from the operating rod.

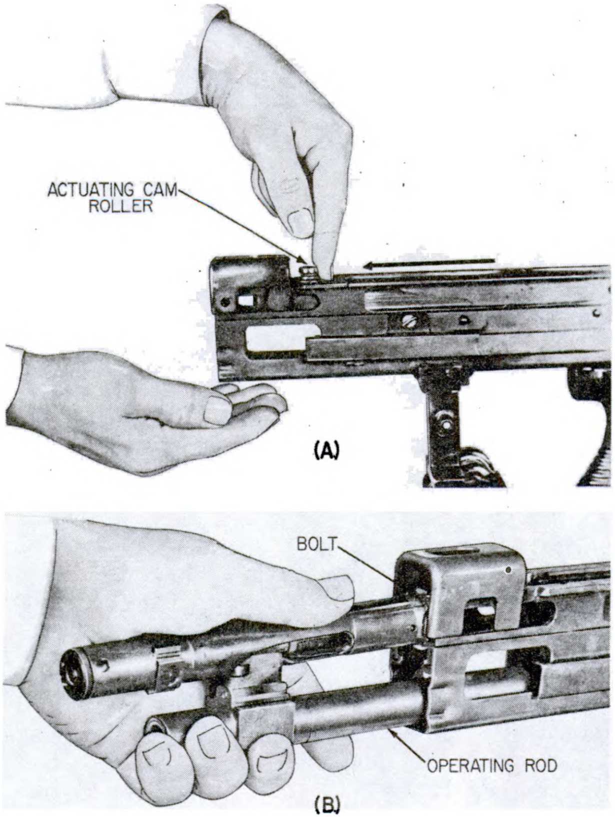


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Figure 13-62.—Removing the operating group.

REMOVING THE TRIGGER HOUSING GROUP.—A detailed view of the trigger housing group is shown in figure 13-63. The trigger housing pin and the sear pin are interchangeable. To remove this group, refer to figure 13-64.

First, press in on the rear of the leaf spring. Rotate the rear end of the spring down to clear it from the sear pin. (Refer to view A.) Pull aft to disengage the spring's front notch from the trigger housing pin. Remove the trigger housing pin by pushing it to the left. Slide the trigger housing slightly forward. Then rotate the front of the housing down and remove it. (Refer to view B of figure 13-64.)

REMOVING THE BARREL GROUP.—The barrel group consists of the barrel, flash suppressor, front sight bipod assembly, and gas cylinder. To remove this group, raise the barrel lock lever to its vertical position. Remove the barrel group by pulling it to the front as shown in figure 13-65.

General disassembly to this point leaves the receiver group intact. No further disassembly is required to do general maintenance and cleaning actions. A detailed view of the receiver group components is given in figure 13-66. Note the nomenclature of the receiver's parts.

Assembly of the M60 Machine Gun

The assembly procedures for the M60 machine gun are basically the reverse of the steps taken during disassembly. Starting with the receiver, each group is attached in the following manner:

1. Refer to figure 13-65. Ensure that the barrel lock lever is in the vertical position. Insert the rear of the barrel under the barrel cover. Align the gas

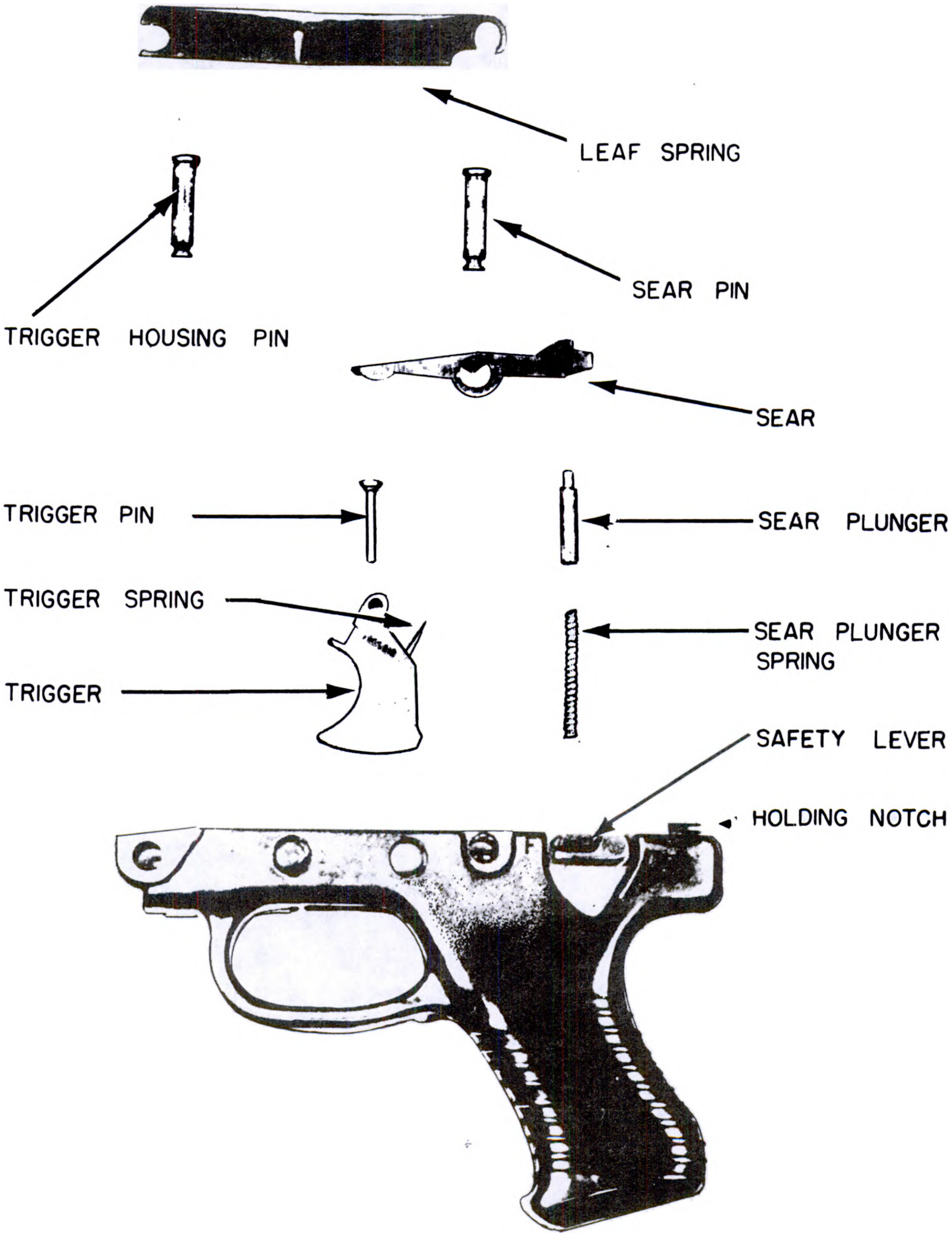

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Figure 13-63.—Trigger housing group; disassembled.

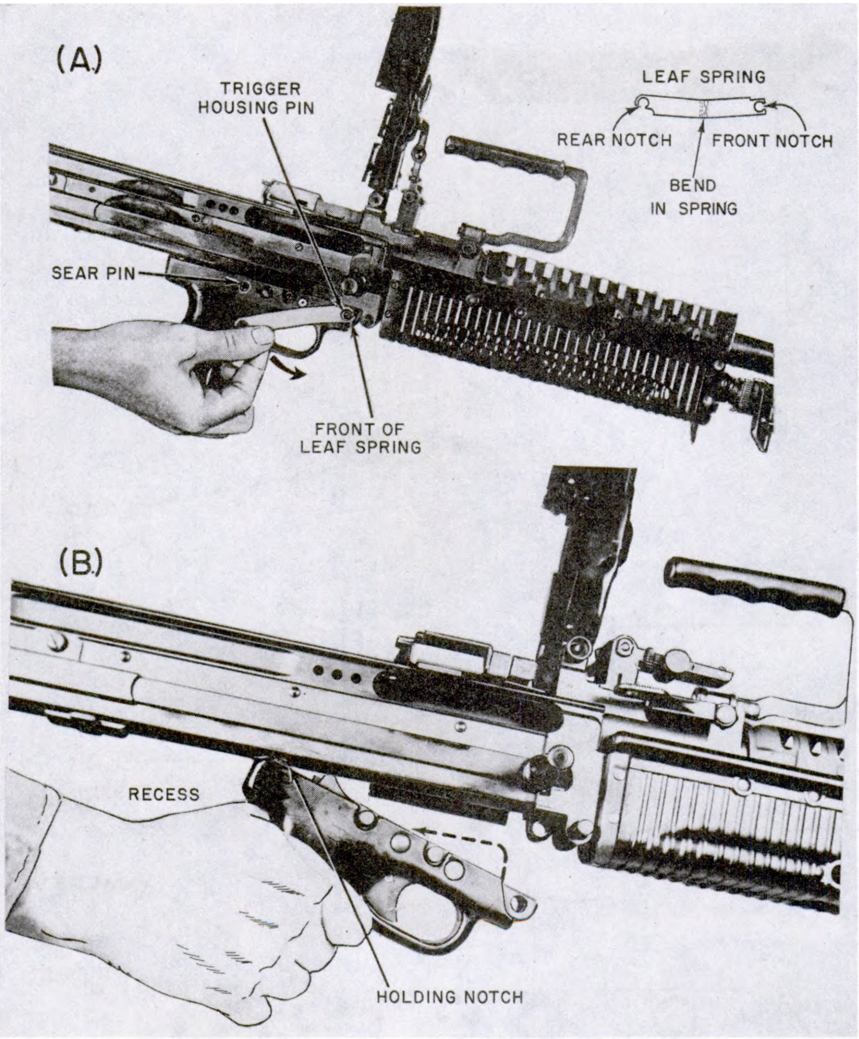
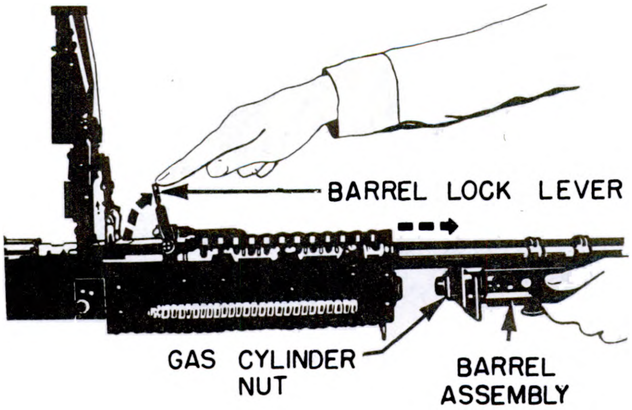


Figure 13-64.—Removing the trigger housing group. 220.65



220.66
Figure 13-65.—Removing the barrel group.

cylinder nut with its recess in the forearm assembly. Lower the barrel lock lever.

2. Engage the holding notch of the trigger housing into its recess in the bottom of the receiver (view B of figure 13-64). Rotate the front of the trigger housing up and align its holes with the mounting bracket on the receiver. Insert the trigger housing pin from the left. Engage the front of the leaf spring with the trigger housing pin (view A of figure 13-64). Ensure the leaf spring is positioned so that the bent portion is pressed against the side of the trigger housing. Rotate the rear of the leaf spring up and engage it with the sear pin.

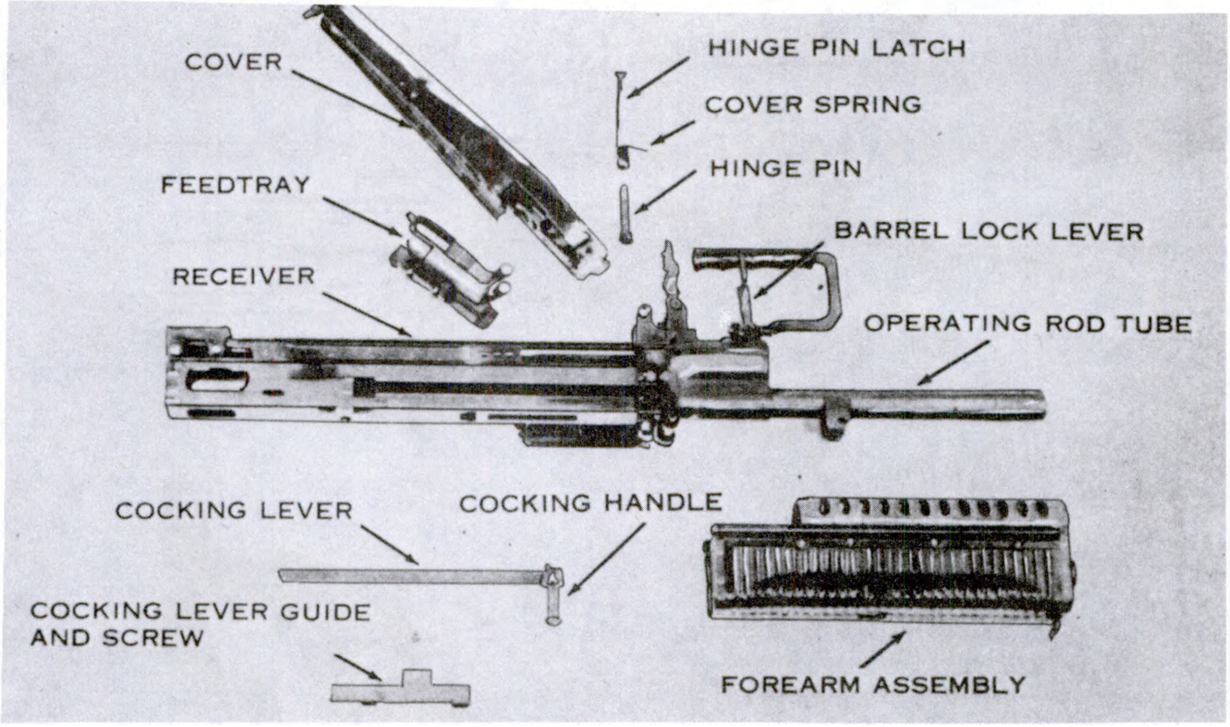


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Figure 13-66.—Receiver group; disassembled.

3. Insert the end of the operating rod into the receiver (view A of figure 13-67). Hold the rod with one hand. With the other hand, push forward on the rear of the bolt. This causes the bolt to rotate until the locking lugs are in a vertical position. With the cam roller up, push the operating rod and bolt into the receiver. Carefully do so until the end of the operating rod is even with the rear of the receiver. (Refer to view B of figure 13-67.) Insert the drive spring guide into the drive spring. Then insert the opposite end of the drive spring in the recess of the operating rod. Pull the trigger and push the drive spring in. Do so until the head of the guide is about 1 inch from the receiver. The drive spring guide position should be as seen in view B of figure 13-61.

4. Insert the buffer plunger into the drive spring guide. (Refer to view B of figure 13-61.) Push forward on the buffer until the operating rod and bolt go fully forward. Push in on the buffer until the recesses on the buffer are aligned with the recesses in the receiver. Replace the buffer yoke from the top of the receiver. (Refer to view A of figure 13-61.)

5. Align the guide rails of the stock with the guide rails on the receiver. Push forward until the stock is fully seated. A distinct click will be heard when the latch engages. (Refer to figure 13-60.)

6. To check for correct assembly, pull the cocking handle to the rear and return it to its forward position. Close the cover and pull the trigger. The bolt should go forward.

SPECIAL ACCESSORIES AND DEVICES

The following sections of the text will examine three special subject areas. They are closely related to the topic of small arms and, as a GM, you will be involved with them. First, we'll study the Mk 87 Mod 1 line-throwing rifle adapter kit. Then we'll take up the 40-mm M79 grenade launcher and hand grenades (in general).

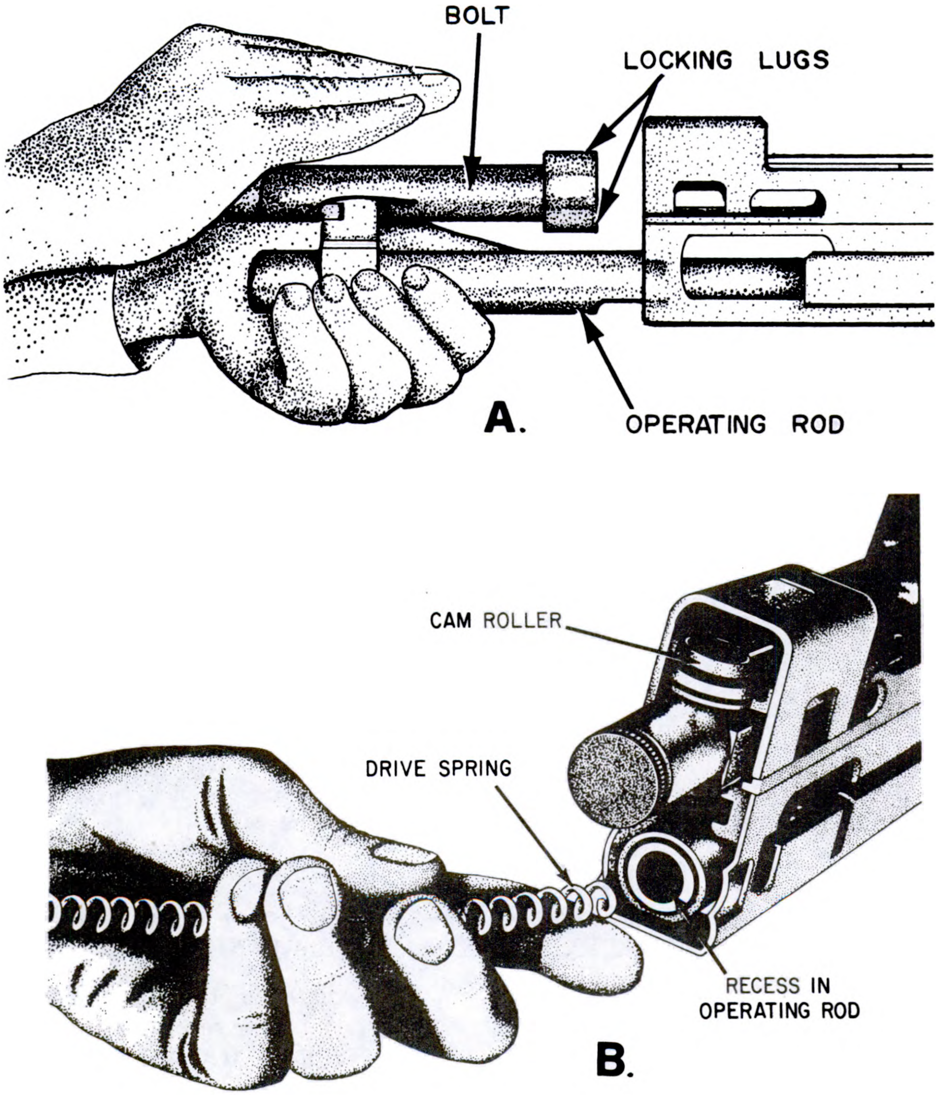

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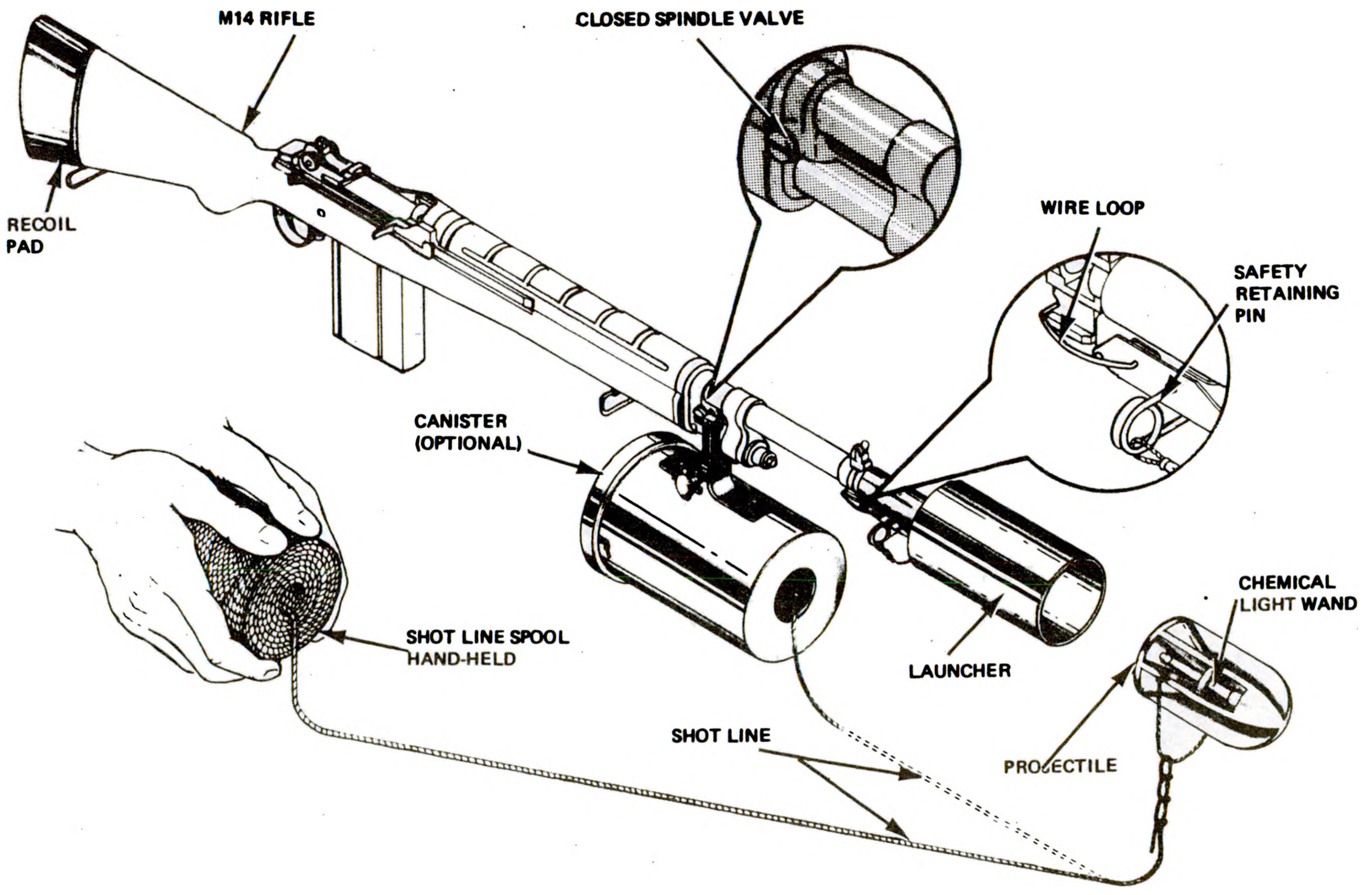
Figure 13-67.—Replacing the operating group.

THE MK 87 MOD 1 LINE-THROWING RIFLE ADAPTER KIT

The act of line-throwing involves passing a small line between two points (ship to ship, ship to shore, etc.). The small line then serves as a messenger for larger lines. This small line is commonly known as "shot line" because it is shot from a gun. Each time your ship participates in a connected underway replenishment or enters/leaves port, the line-throwing gear is readied. It is your job as a Gunner's Mate to have this equipment on station and to be ready to use it.

The Mk 87 Mod 1 line-throwing rifle adapter kit is currently being issued to the fleet. It replaces the Mk 87 Mod 0 kit and the older .45-cal line-throwing gun. The Mk 87 Mod 1 kit is designed to be used with the M14 and M16 rifles. Figure 13-68 shows the major component parts of the kit installed on an M14 rifle.



84.495

Figure 13-68.—The Mk 87 Mod 1 line-throwing kit; installed on an M14 rifle.

Launcher

The launcher (figure 13-69) is used to hold the projectile and trap propellant gases which propel the projectile. The launcher consists of a cylindrical steel tube about 8.5 inches long. It is 2.75 inches in diameter at the launching end and 1 inch in diameter at the connecting end. When used with the M14 rifle, the launcher is secured to the rifle by the latch and wire loop. The wire loop fits over the rifle's bayonet lug. (Refer to figure 13-14.) The safety retaining pin is fastened to the launcher by a stainless steel lanyard. The pin fits through the latch to lock the launcher to the rifle.

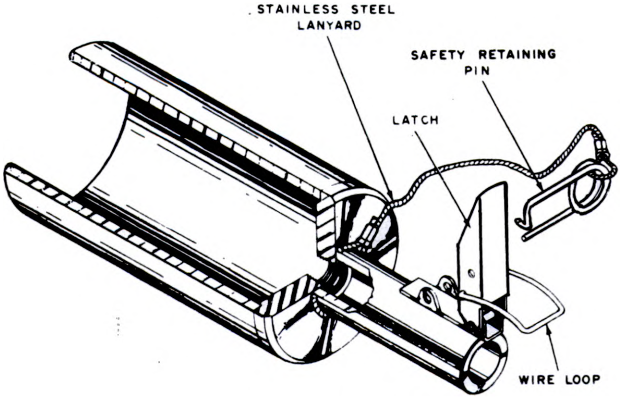


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Figure 13-69.—Launcher.

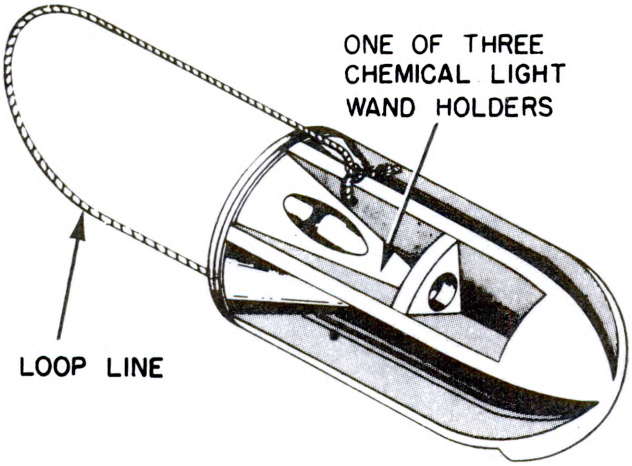

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Figure 13-70.—Projectile.

Projectile

The projectile (figure 13-70) fits into the launcher. When the rifle grenade cartridge is fired, the projectile carries one end of the attached shot line to the desired destination. (That depends on how good a shot you are, of course!) The projectile also houses the chemical light wands for night operation.

The reusable projectile is made of Butyl rubber with a stainless steel disk assembled in the base end. The disk absorbs the impact of the propellant gases and the wadding of the rifle grenade cartridge. The hole and groove shown in figure 13-70 support a light wand. Three of these supports, located 120° apart, are contained in each projectile. The loop line is used to connect the shot line to the projectile.

Chemical Light Wand

The chemical light wand (view A of figure 13-71) is used to illuminate the projectile during night operations. The light wand is inserted, tapered end first, into the hole and groove of the projectile.

The light wand is a two-component chemical illuminant system. It consists of a yellow-green oxalate solution inside a nylon tube. To activate the light, flex the nylon tube enough to break the inner glass tube (view B of figure 13-71). Then shake it vigorously to mix the chemicals. Do not activate the light wand until you're ready to use it. Once it is activated, it must be used or disposed of properly. Do NOT dispose of the chemical light wand overboard as it may be mistaken for a "man overboard" exercise/signal. If the nylon tube should puncture during activation, some mild discomfort from excessive skin or eye exposure to the oxalate solution may be experienced. Personnel should wash exposed areas with soap and water as soon as possible.

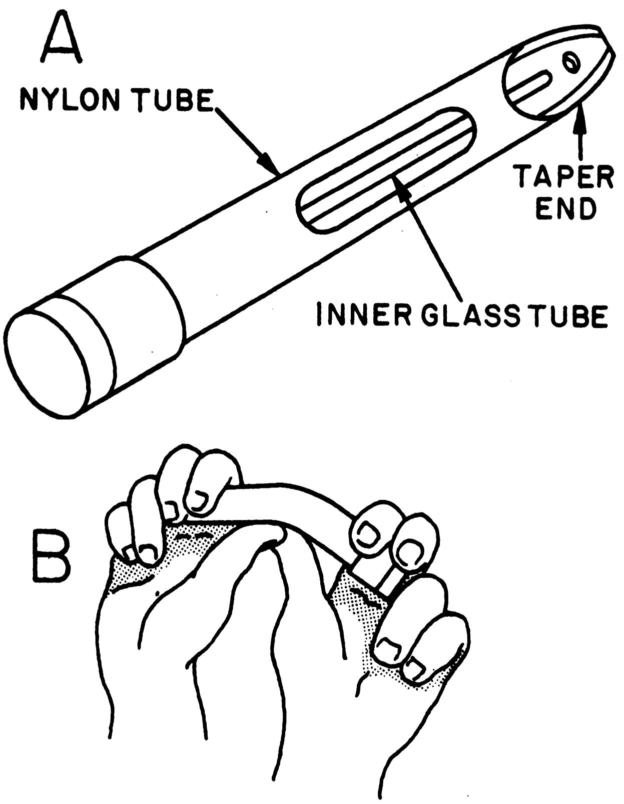

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Figure 13-71.—View A—the chemical light wand; View B—activating the wand.

Since the chemical light produces no flame or heat, its stowage is not restricted to ventilated and unconfined (topside) spaces. The active life of the chemical light is from 3 to 12 hours, depending on the ambient temperature. Its shelf life is about 2 years under normal conditions.

Canister

The canister (figure 13-72) is made of polyethylene and houses the spool of shot line when attached to the rifle. Attachment is made by the metal clamp shown in figure 13-72.

To install the shot line, remove the cap from the after end of the canister. Place the spool of shot line in the canister and feed the line from the center of the spool through the hole in the front of the canister. Tie a knot in the bitter end of the shot line. Slide the knot into the elongated slot at the after end of the canister and replace the cap. (That action attaches the bitter end of the shot line to the canister.) Connect the line coming from the front end of the canister to the loop line on the projectile. These lines (shot line and loop line) are connected by a series of loosely tied half-hitch knots (three to five).

Figure 13-68 shows the canister, shot line, and launcher mounted on the M14 rifle. Note in the figure that the use of the canister is optional. With another person holding the shot line, the canister is not needed.

Recoil Pad

The recoil pad provided with this kit will reduce the force of recoil on the shooter when the projectile is launched. The pad is made of neoprene rubber to resist attacks by oil and other solvents. It is a slip-on type of pad designed for a tight fit on the butt of the stock. Take care not

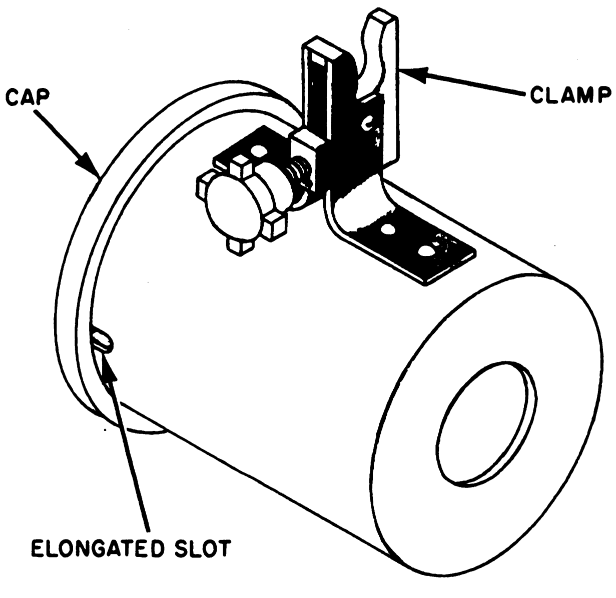

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Figure 13-72.—Canister.

to tear the pad when you are installing it. Usually, the ship will designate one or two M14 rifles as the "duty" line-throwing guns. That eliminates the need to install/remove the pad continually.

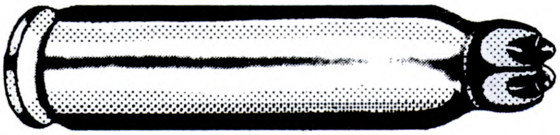

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Figure 13-73.—M64 grenade cartridge for M14 rifle.

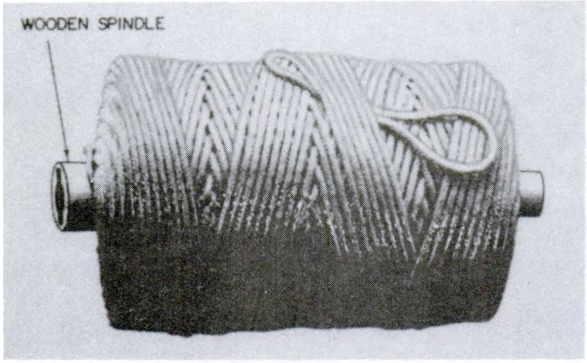

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Figure 13-74.—Shot line spool.

Grenade Cartridges

Figure 13-73 depicts the grenade cartridge used with the M14 rifle when firing the line-throwing projectile. The M64 (7.62-mm) grenade cartridge can be identified by looking at or feeling its tip. The M64 has a five-pointed crimped end. Only one cartridge should be loaded into the rifle at a time. It should not be loaded until just before the weapon is fired. The rifle should be pointing outboard in a safe direction. No cartridge other than the one designated shall EVER be used to fire a line-throwing projectile.

Shot Line

The nylon shot line comes in spools (figure 13-74) about 550 feet long. The line has a tensile strength of about 125 pounds. It is wound around a wooden spindle in a way that prevents fouling when the projectile is fired. The line is colored international orange for high visibility. It is also treated with a water-repellent solution to make the line buoyant enough to float on the surface at least 24 hours. The shot line can be rewound on the spool either by hand or with a special rewind machine.

Preparation for Firing

On the M14 rifle, the spindle valve must be in its off (slot parallel to the barrel) position when

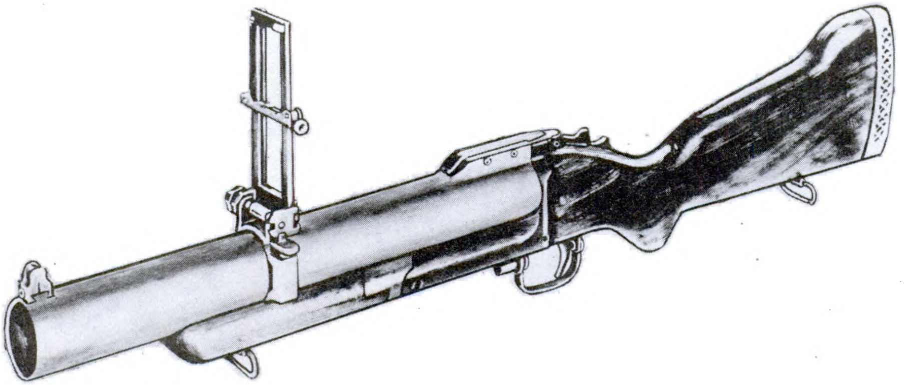

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Figure 13-75.—The M79 grenade launcher; rear sight assembly raised.

Table 13-1.—Range Data

M14 RIFLE	
Degrees of Elevation	Range
60°	80 Yards
45°	90 Yards
30°	85 Yards
0°	55 Yards

NOTE: 0°(degrees) is when the rifle is parallel to the surface.

firing the line-throwing projectile. (Refer to figure 13-20.) Double-check all connections to ensure they are secure. When firing the line-throwing projectile from the M14 rifle, elevate and aim the rifle over and across the designated target. Although the projectile is made of rubber, it has enough velocity to cause serious personnel injury. The rifle should be kept elevated until the projectile reaches its target. That prevents the line from fouling.

In the event of a misfire or hangfire, wait 10 seconds before ejecting the grenade cartridge from the rifle. Cartridge malfunctions must be reported in accordance with OPNAVINST 5102.1.

The maximum reliable range of the line-throwing projectile is about 90 yards when fired from the M14 rifle. That range is dependent upon having dry shot line. A wet line can be used when dry line is not available. However, it will cause the range to be reduced. Table 13-1 provides the approximate range data for firing from the M14 rifle.

THE 40-MM M79 GRENADE LAUNCHER

The M79 grenade launcher (figure 13-75) is a break-open, single-shot weapon. It is breech loaded and chambered for a 40-mm metallic cartridge case with internal primer. Cartridges used with the M79 grenade launcher are shown in figure 13-76.

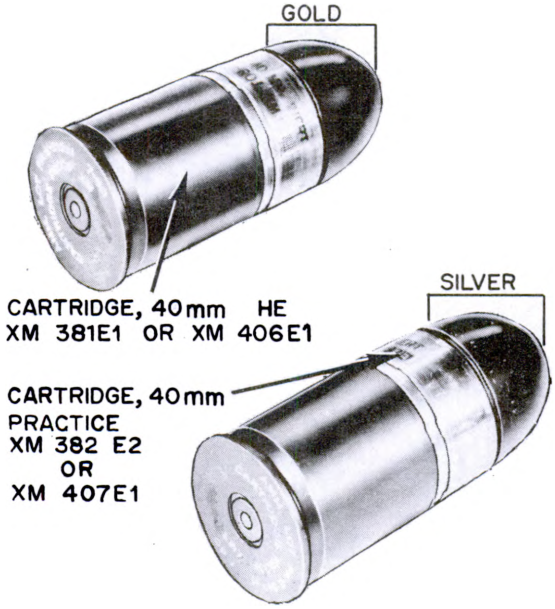

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Figure 13-76.—Cartridges used with the M79 grenade launcher.

Controls of the M79 Grenade Launcher

The safety (figure 13-77) is in the safe position when pulled all the way back. It is in the firing position when pushed all the way forward.

The barrel locking latch can be pushed to the right. That permits the breech end of the barrel to be swung up into its open position. The grenade launcher cocks as it opens. Also, the safety is moved to its safe position when the breech is opened.

The trigger guard assembly has two positions. It is shown in the lowered (or down) position in figure 13-77. The guard can be released by pushing back on the detent housing piece. Once released, the guard can be swung to either side, making it possible for a person wearing heavy gloves or mittens to fire the grenade launcher. The sighting equipment for the launcher is shown in figure 13-78.

Operating the M79 Grenade Launcher

The following procedures should be followed when loading and firing the M79 grenade launcher.

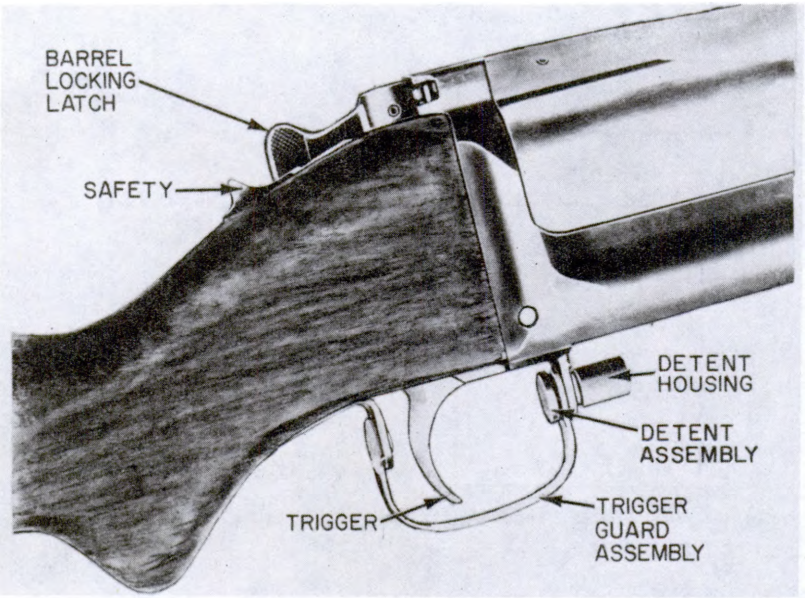

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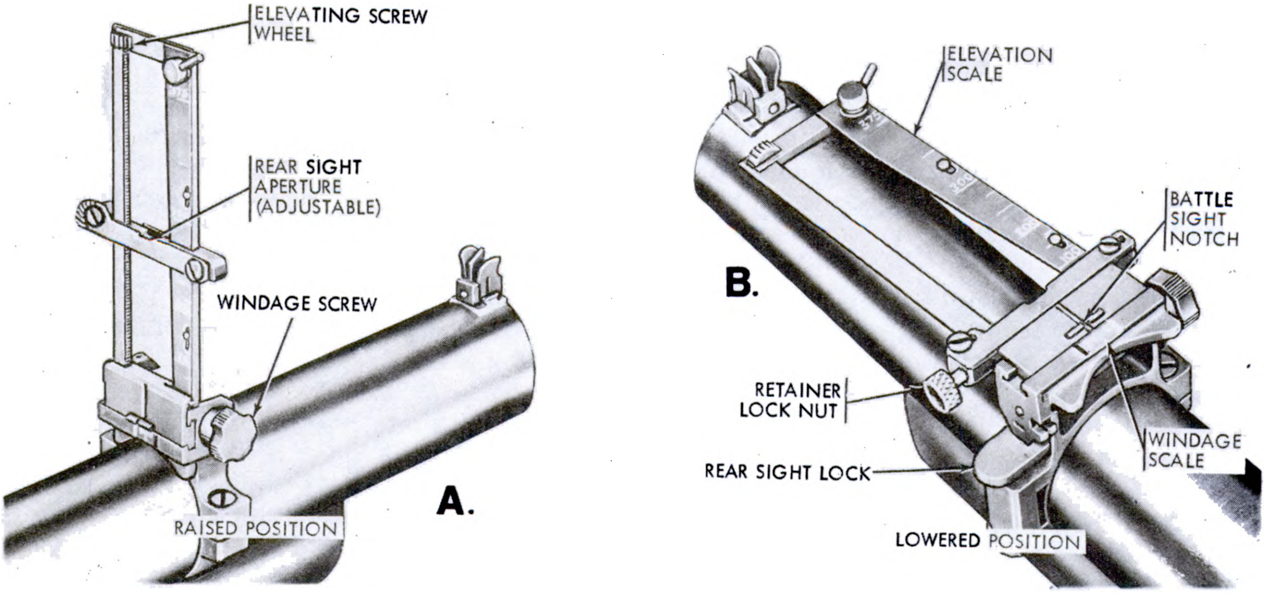
Figure 13-77.—Grenade launcher controls.



29.365

Figure 13-78.—Rear sight assembly.

Check the bore to be sure it is free of foreign matter or obstructions. Check all ammunition to be sure the proper type and grade are being used. Check the launcher to be sure it is properly cleaned. Inspect for malfunctions and other defects.

Point the muzzle of the launcher toward the ground and clear the immediate area of all unnecessary personnel. Move the barrel locking latch all the way to the right and break open the breech. If the safety was not already on safe, this procedure will cause it to move to safe. However,

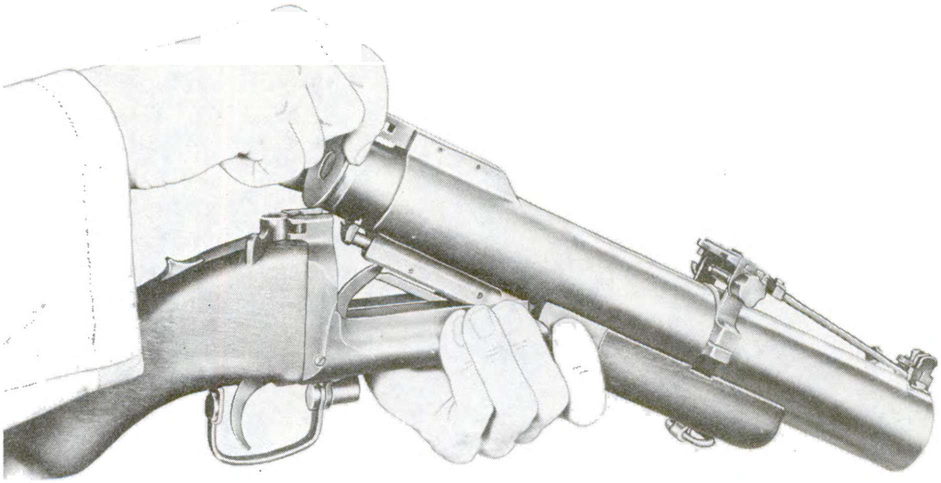


Figure 13-79.—Loading. 29.366

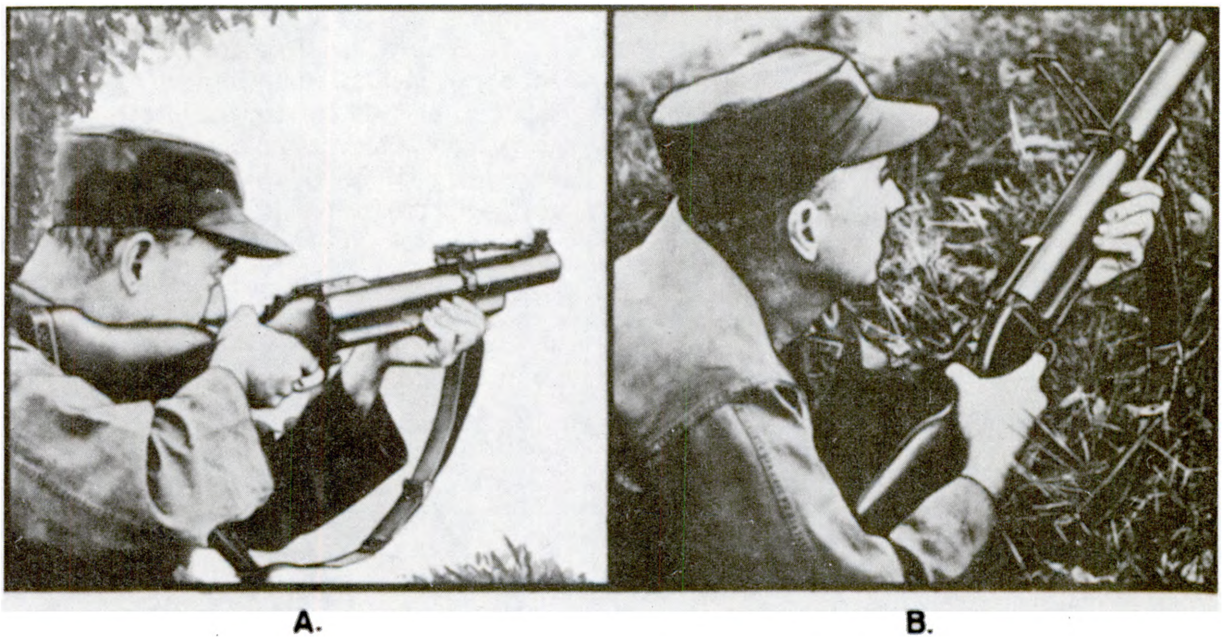


Figure 13-80.—Firing positions: A. Standing; B. Prone. 29.367

the barrel locking latch has to be moved to its full limit of travel.

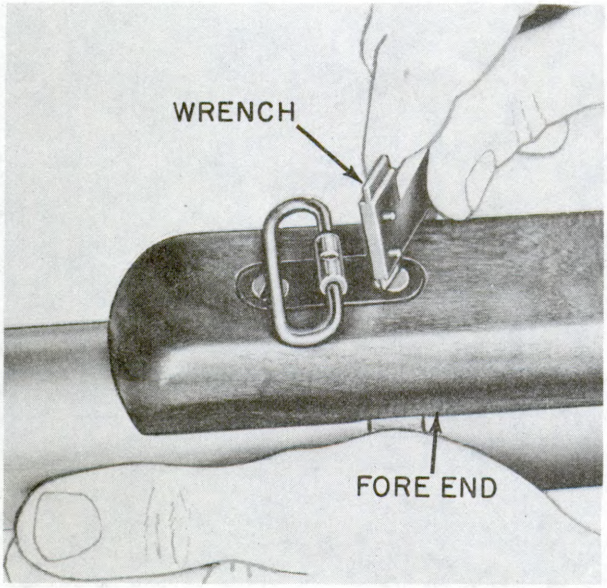
Insert the projectile into the chamber opening (figure 13-79). Push the complete round forward into the chamber until the extractor contacts the rim of the cartridge case. Close the breech by carefully pulling up on the front end of the weapon.

When the launcher is fired, you must be in either a standing or prone position. In the standing position, the butt is placed against the shoulder. In the prone position, the butt is placed against the ground/ship's deck. (Refer to figure 13-80.)

A detailed discussion of sightsetting is beyond the scope of this manual. However, for targets at ranges from 50 to 80 meters (165 to 265 feet), the rear sight frame assembly must be placed in its lowered position. (See view B of figure 13-78.) This position is called the "battle sight" position.

Longer ranges are fired with the rear sight frame in the upright position. See view A of figure 13-78. The sight aperture bar set must be to the approximate target range on the scale. TM 9-1010-205-10 provides detailed instruction on use of the launcher's sights.

When firing grenades at targets within battle sight ranges (50 to 80 meters), the operator must be in a protected position. Targets within 80 meters of friendly troops must not be fired upon.



29.369

Figure 13-81.—Removing the screw that secures the fore-end assembly to the barrel.

Field-Stripping the M79 Grenade Launcher

Field-stripping the M79 grenade launcher consists of two general actions. First, the fore-end assembly is separated from the barrel and receiver group. Second, the stock is separated from the receiver group.

To remove the fore-end assembly, use the special wrench assembly shown in figure 13-81. Remove the machine screw as illustrated. Pull the front end of the fore-end assembly away from the barrel (figure 13-82). Do so until the lug on the rear sight base is clear of the hole in the upper surface of the fore-end bracket. Keeping the lug

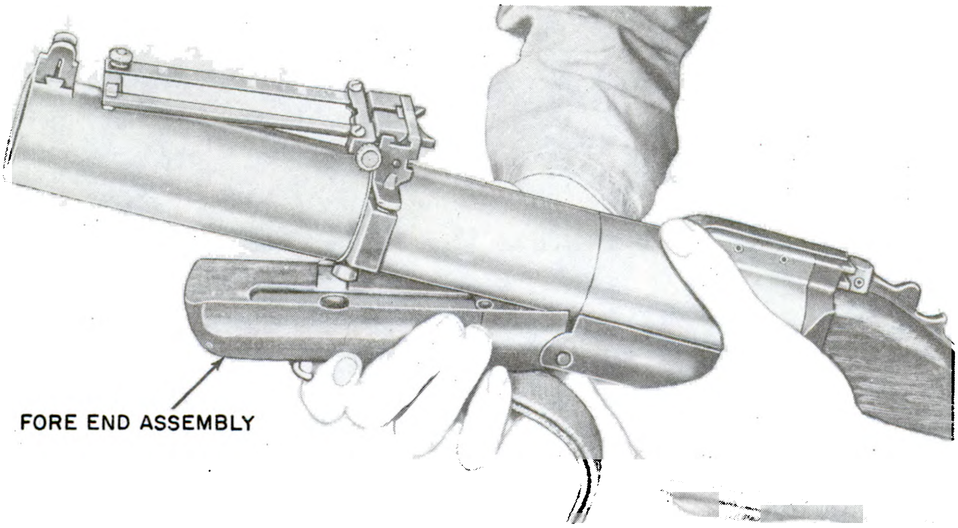


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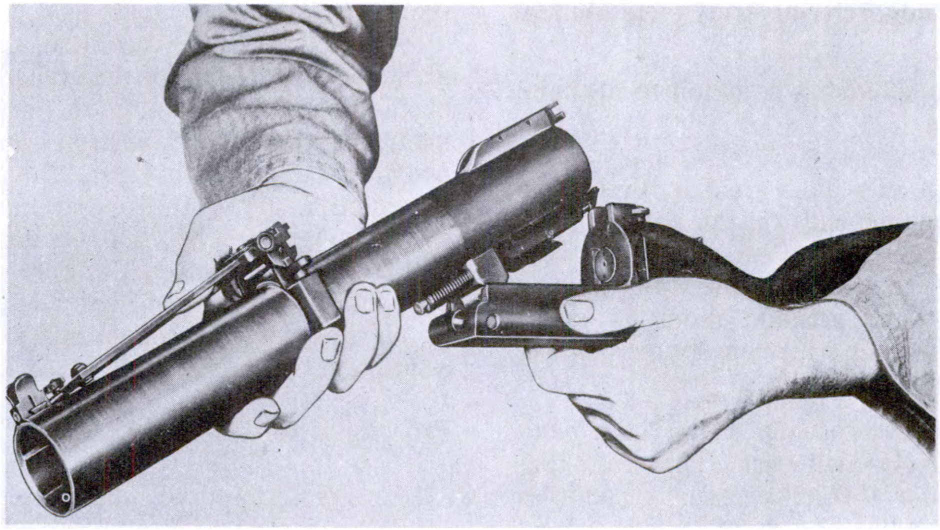
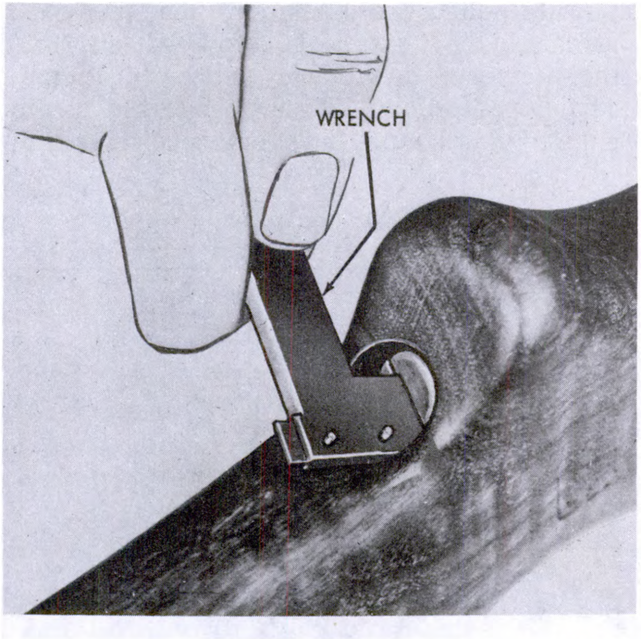
Figure 13-82.—Removing the fore-end assembly.



29.371

Figure 13-83.—Removing the barrel group.



29.372

Figure 13-84.—Removing the screw that secures the receiver group to the stock assembly.

clear of the hole, pull forward on the fore-end assembly until it is free of the receiver assembly.

To remove the barrel group from the receiver group, first actuate the barrel locking latch and open the breech. Holding the stock and receiver stationary, move the barrel rearward in the receiver. Do so until it is disengaged from the fulcrum pin (figure 13-83). Separate the barrel from the receiver group.

To separate the stock from the receiver group, use the special wrench assembly as shown in figure 13-84. Remove the machine screw which secures the stock to the receiver group and separate the two components.

HAND GRENADES

A hand grenade is a small bomb. The user's arm provides the motive power to get it to the target. Hand grenades may be filled with explosives or explosives and chemicals. For practice purposes, grenades may be empty or contain an inert filler. Hand grenades come in many sizes, shapes, and types. They can be used to inflict material damage and personnel casualties. Hand grenades are also useful for screening, signaling, and illuminating actions.

Types and Characteristics

The general types of hand grenades issued are (1) training, (2) practice, (3) fragmentation, (4) offensive, (5) chemical, and (6) concussion. Each type is designed to do a special job. For a summary of the characteristics and capabilities of each hand grenade, refer to Army Field Manual FM 23-30.

Certain characteristics common to all hand grenades follow:

1. The range of a hand grenade is relatively short. The range depends on the ability of the individual and the shape of the grenade. A well-trained sailor should be able to throw a fragmentation hand grenade about 44 yards. However, the heavier white phosphorus smoke grenade may go only about 27 yards.

2. The effective casualty radius of a hand grenade is relatively small when compared to that of other weapons. Effective casualty radius is defined as the radius of a circular area around the point of detonation. Within that area, at least 50 percent of the exposed personnel will become casualties. The effective casualty radius varies with the type of hand grenade used. Therefore, casualties can and do occur at distances greater than that radius.

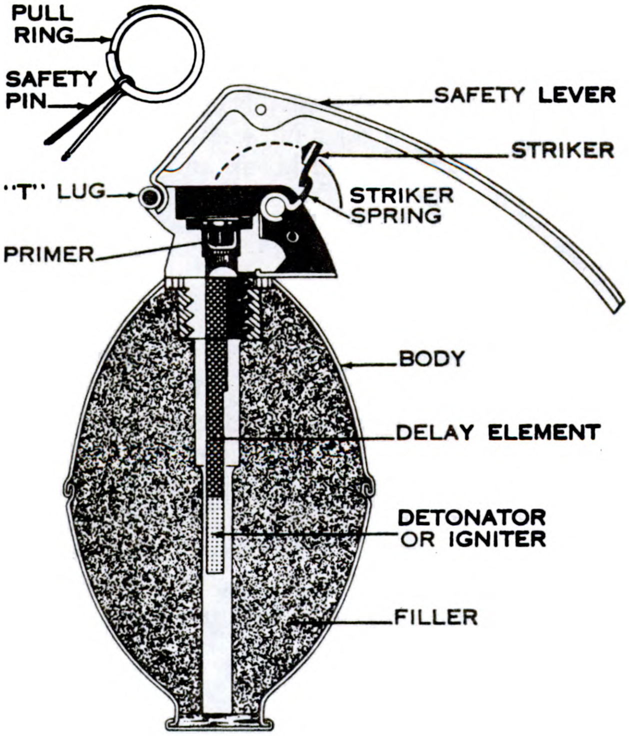


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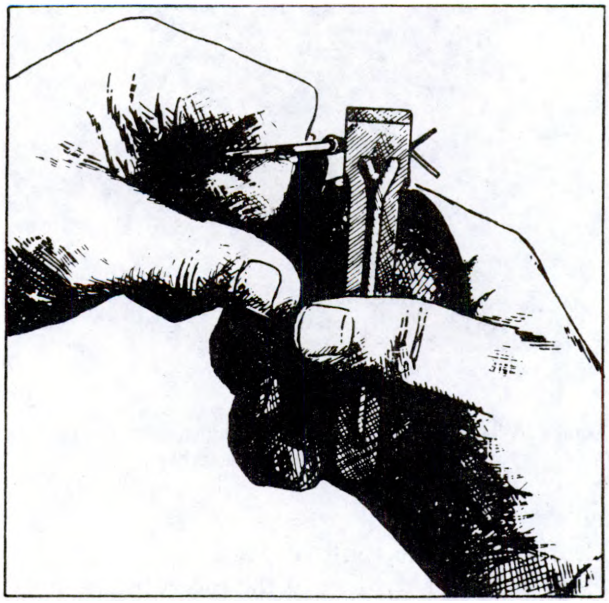
Figure 13-85.—Typical hand grenade; functioning of the fuse.

3. Delay fuzes are used in all standard hand grenades. Detonation of the grenade does NOT occur on impact. Detonation occurs after the delay element in the fuze has burned. The fuze assembly can be seen in figure 13-85. For further information about the operation of the fuze assembly, refer to FM 23-30. Casualty-producing grenades (fragmentation, offensive, and white phosphorus) have a 4- to 5-second delay. Because of this short delay, personnel must stay alert when arming and throwing hand grenades.

Procedures for Throwing

For greater accuracy and range, the grenade should be thrown like a baseball, using the throwing motion most natural to the individual. It is important to grip the grenade properly. Figure 13-86 shows the proper position of the grenade prior to pulling the safety pin. First, cradle the grenade in the fingers of the throwing hand. Hold the safety lever down firmly under your thumb. The grenade should fit snugly into the curved palm of your hand. That should give you a firm



84.18

Figure 13-86.—Proper way to grip the hand grenade.

and comfortable grip. Do NOT relax your thumb pressure on the safety lever UNTIL you throw the grenade.

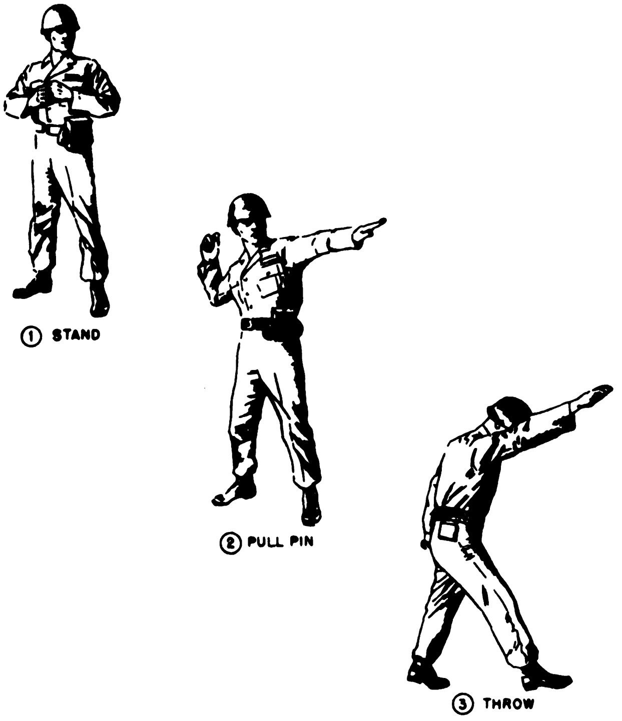
The main steps in grenade throwing are to develop good throwing habits and several throwing positions. Four throwing positions—standing, kneeling, prone, and crouch—are recommended.

The procedures for throwing from the standing position are as follows:

1. Stand half-facing the target with your weight balanced equally on both feet. Hold the grenade chest high, using the correct grip (view 1 of figure 13-87).

2. Remove the pin with a twisting, pulling motion. Cock your throwing arm to the rear (view 2).

3. Throw the grenade with a free and natural motion. As it leaves your hand, follow through by stepping forward with your rear foot (view 3). Observe the point for probable impact, then take cover to avoid fragments or other blast effects.



84.19

Figure 13-87.—Throwing the hand grenade from the standing position.

Field Manual 23-30 explains the proper steps to be taken when using any of the other positions.

Safety

The following safety precautions must be observed when handling or using hand grenades:

1. Do not take any grenade apart unless ordered to do so by competent authority.

2. Do not tamper with grenades. Do not recover or tamper with live grenades that fail to explode (duds). These duds must be recovered and destroyed only by qualified personnel.

3. Do not pull the safety pin until you are ready to throw the grenade. If the safety pin will not pull out easily with a pulling-twisting motion, straighten its ends. Maintain a firm grip on the safety lever when removing the safety pin.

4. After you pull the safety pin, throw the grenade. Do not attempt to replace the pin to return it to a safe condition.

5. When throwing a fragmentation grenade without protective cover, drop immediately to a prone position, face down. Point your helmet toward the grenade. Keep your arms and legs flat against the ground. Other personnel in the area who are exposed must be warned to drop to a similar position. Steel helmets and body armor must be worn at all times when using grenades.

6. Although little danger is involved in using practice hand grenades, they require some degree of care in handling and throwing. You can throw the practice grenade a safe distance but, for the purpose of training and to preclude injury from an improperly loaded grenade, take cover. Wear the steel helmet and keep all other personnel at a safe distance. Do not recover practice grenades for at least 10 minutes after they fail to function (duds). Again, only trained and qualified personnel are permitted to handle these duds.

7. Grenades are issued in the "with fuze" and "without fuze" condition. They are not necessarily shipped in separate containers. The detonator of a fuze is very sensitive to heat, shock, or friction. The safety precautions and steps to be taken when fuzing hand grenades are explained in FM 23-30.

SPECIAL PRECAUTIONS FOR SMALL ARMS

Semiautomatic and automatic weapons, in the hands of inexperienced or careless persons, are largely responsible for the old saying, "It's always the unloaded gun that kills." It is a fact that many accidental deaths and injuries are caused by the mistaken belief that removing the magazine of the weapon is all that is necessary to unload it. Nothing could be further from the truth.

To unload a pistol or other magazine-fed weapon completely and render it safe to handle, two actions are required. First, it is necessary to remove or empty the magazine. Second, it is necessary to make absolutely certain the chamber is empty. The only way that can be done when handling the .45-cal pistol, for example, is to pull back the slide and inspect the chamber. The inspection can be performed visually or, if it is dark, by feel. The magazine should be removed and the muzzle pointed in a safe direction. If the chamber is loaded, the round can be extracted and ejected when the slide is operated.

"I didn't know it was loaded" is never an excuse for the accidental discharge of a weapon—especially for a Gunner's Mate. The .45-cal pistol must be considered loaded when the slide is forward and/or the magazine is in the weapon. It is only safe when the slide is locked in the open position, the magazine is out of the weapon, and the chamber is verified to be empty.

When handling revolvers, a simple visual inspection is sufficient to determine if any chambers in the cylinder are loaded. Keep the hammer fully down when the pistol or revolver is not loaded. When the pistol is cocked, keep the safety lock in the on (safe) position and the weapon pointed in a safe direction.

Let us briefly review some of the safety precautions that apply to the handling of all small arms:

1. Never point a weapon at anyone unless your intent is to kill.
2. Unless the weapon is to be used immediately, never carry it with a round in the chamber.
3. Unless you are about to fire the weapon, the safety of every small-arms weapon must be in the safe position. Always keep your finger AWAY from the trigger. When the safety is moved to the fire position, many small arms will fire if the trigger is pressed as the safety is released.
4. Consider a gun loaded until you have opened the chamber and personally verified that it is empty. It is not enough to wail afterward, "I didn't know it was loaded." The "empty" weapon is the dangerous one.
5. Before firing any weapon, be sure there are no obstructions in the bore.
6. Before firing any weapon, be sure the ammunition you are using is the right ammunition. For example, the M14 rifle ammunition cannot be used in the M16 rifle.
7. Before firing, be sure there is no grease or oil on the ammunition or in the bore or chamber. Although lead bullets may be lightly waxed or greased, there must never be any lubricant on the cartridge case. (This does not apply to aviation ammunition.) Lubricant on the case or in the chamber is particularly bad. Upon firing, the case slips backward, causing a dangerously heavy thrust against the bolt.
8. Keep ammunition dry and cool. Keep it out of the direct rays of the sun. Keep ammunition clean, but do NOT polish it or use abrasives on it. Do not attempt to use dented cartridges, cartridges with loose bullets, or cartridges eaten away by corrosion. Be particularly careful with tracer ammunition. It can ignite spontaneously if damp.
9. Misfires and hangfires can occur with small-arms ammunition. On some weapons, you can recock and attempt to fire again without opening the breech. If after a couple of tries this proves unsuccessful, or if the weapon cannot be recocked without opening the bolt, wait at least 10 seconds. Then open the bolt and eject the defective round. Defective small-arms ammunition should be disposed of following current regulations.

A misfire with blank cartridges may leave unburned powder deposited in the bore. Always check the bore after any misfire and clean it if necessary.

10. Guard against blowback. In this sense, blowback refers to leakage of high-pressure gases around the closed bolt. It can be caused either by excessive wear of the bolt or chamber, by

obstructions that foul the bore, or by both. Blowback can be avoided by gaging and checking your weapons regularly. Replace worn parts as indicated and check to be sure there are no obstructions in the bore.

STOWAGE AND ISSUE OF SMALL ARMS

As a GM, you are responsible for the security, stowage, maintenance, and issue of your command's small arms. An increasing number of reported instances of ammunition and weapon pilferage by dissident groups and individuals is occurring. That makes it necessary for stricter control of stowage, security, custodial responsibility, and inventory reconciliation procedures. These stricter controls apply to all weapons and ammunition stowed in your armory. Small arms must always be stowed in an authorized and secure location to preclude pilferage. A strict accountability must be maintained at all times.

All small arms are considered equipage. A signature of subcustody is required before small arms are issued from their normal place of stowage. It is important to get the signature of the person receiving the weapon. Any type of signed custody record may be used as long as it bears the receiving individual's signature. Again, the important security measures are to keep the weapon locked up and, when it is issued, to get a signature.

REFERENCE SOURCES

The following sources were used to develop the material of this chapter.

1. NAVEDTRA 10199-C, *Gunner's Mate M 3 & 2*
2. NAVEDTRA 10185-C, *Gunner's Mate G 3 & 2*
3. NAVEDTRA 10345-D, *Aviation Ordnanceman 3 & 2*
4. FM 23-45, *Pistols and Revolvers* (for the .45-cal pistol and the .38-cal Smith and Wesson revolver.)
5. TMSDA84-1, *Ruger Service-Six Military Model Double Action Revolvers Caliber .38 Special*
6. FM 23-8, *M14 and M14A1 Rifles and Rifle Marksmanship*
7. FM 23-65, *Browning Machinegun Caliber .50 HB, M2*
8. FM 23-67, *Machinegun 7.62-MM, M60*
9. FM 23-31, *40-MM Grenade Launcher M203 and M79*

CHAPTER 14

MISSILE HANDLING AND MAGAZINES

Some very important aspects of your rating will be addressed in this chapter. The first topic deals with ammunition handling. Ammunition may be broadly defined as any device containing explosive material(s). Consider the following examples or classes of naval ammunition:

1. Gun ammunition
    a. Separated—case- and bag-type
    b. Fixed
    c. Small-arms (really a subclass of fixed ammunition)
2. Bomb-type ammunition
    a. Torpedo warheads
    b. Aircraft bombs
    c. Mines
3. Pyrotechnic devices
4. Rocket ammunition
5. Impulse ammunition
6. Demolition charges and components
7. Guided missiles

Obviously, we will concentrate on guided missile handling details. However, as a Gunner's Mate, you WILL handle other types of ammunition. Much of the information presented here can be applied to those situations. Handling any explosive material is a serious business.

The second topic area of the chapter deals with shipboard magazines in general. Magazine maintenance is chiefly a matter of inspections, cleaning, and testing. Additionally, there are quite a few regulations pertaining to the interior and exterior conditions of a magazine. We will discuss some of the more important points you need to know.

Needless to say, safety and security are vital factors with all handling evolutions and magazine care. As you study this chapter, remember the explosive materials you encounter deserve your utmost respect. This fact is emphasized in *Ordnance Safety Precautions, Their Origin and Necessity,* NAVORD OP 1014. It presents actual case histories of ordnance mishaps. The written material and accompanying photographs are intended to impress the reader. The point the OP makes is that absolutely uncompromising, rigid adherence to all safety precautions must be practiced constantly. Unfortunately, the publication is somewhat old and hard to come by. If you do, by chance, see a copy, take the time to read it.

MISSILE HANDLING

Where do missiles come from and how do they get aboard ship? As a GM, you must know the answers to those questions. Figure 14-1 illustrates the key steps in the processing and handling of missiles. Study it for a moment. Notice that some of the directional arrows go both ways.

WEAPONS STATION PROCESSING

Guided missiles originate at a naval weapons station (NWS or WPNSTA). It is a shore activity

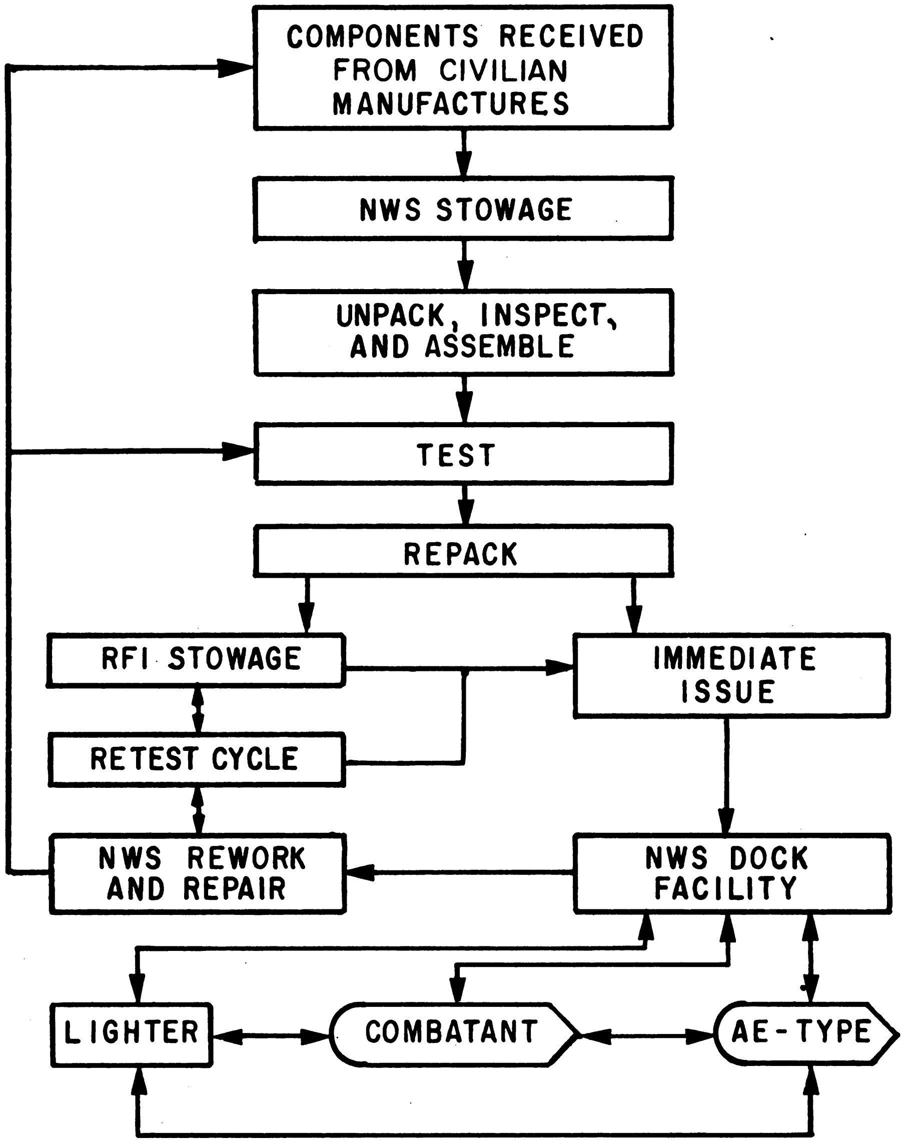


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Figure 14-1.—The major sequences of missile processing and handling.

whose primary mission is to supply the fleet with all types of ammunition. The major NWSs in the continental United States (CONUS) are at Concord, Calif., Seal Beach, Calif., Earle, N.J., Yorktown, Va., and Charleston, S.C. (There are other smaller ammunition handling activities located throughout CONUS and overseas.)

Gunner's Mates are frequently assigned (shore) duty at NWSs. If you get such an assignment, you will be involved with many phases of missile processing. The level of missile maintenance done at an NWS is more detailed and technically oriented than that accomplished aboard ship. The following paragraphs briefly summarize some of the major NWS missile processing events. (Refer to figure 14-1.)

Issue Processing

Individual missile sections are received from civilian manufacturers. When the components arrive at the NWS, they are placed in stowage.

Each component (warhead section, guidance section, etc.) is shipped in its own specialized container. As needed to fulfill fleet missile requirements, the individual components are unpacked and inspected. The sections are tested separately and then carefully assembled to "build" a complete missile.

The fully assembled missile undergoes more testing. Strict quality assurance (QA) standards are checked and double-checked throughout the entire process. When the missile is completely ready, it is certified and classified as an all-up-round (AUR).

The AUR missile is then placed into a missile shipping/stowage container. The round is then transported to either of two locations. If the missile will be issued to the fleet in the near future, it is moved to ready-for-issue (RFI) stowage. Although RFI stowage is only temporary, the weapon will still be checked and inspected regularly.

If the missile will be issued to a fleet unit (ship) immediately, it is moved to the NWS's dock facility. Railroad cars or trucks are used to transport the missile to the loading area/pier. When it arrives at the staging area on the pier, the missile is removed from its container. Normally, the round will be loaded into a missile transfer dolly. The transfer dolly is then moved to the ship, and GMLS strikedown operations take place. (There are other ways to handle missiles on the pier and we'll discuss them later.)

The operation just described could be as simple as delivering one missile to a combatant ship. However, NWSs are capable of replenishing the entire ammunition inventory of any type and size of ship, combatant or otherwise. Ammunition cargo carriers such as AE- and AOE-type ships and especially contracted commercial vessels are major customers at an NWS. Although they carry a much smaller capacity of ammunition, AO- and AOR-type ships also are replenished at an NWS. Occasionally, the NWS will load ammunition onto a lighter (ammunition barge). The lighter is then moved to the receiving ship's location and the ammunition transfer conducted at an anchorage.

Receipt Processing

NWSs are equipped to receive missiles (and other munitions) from fleet units. Missiles returned to an NWS are generally in one of two conditions—serviceable or damaged.

A serviceable missile is one that is still in good shape. It may, however, have reached its expiration date. Usually, the age of a missile's explosive and propellant grains is used to establish a "shelf-life" for the round. Beyond that shelf life, the reliability of the weapon may be in question. So it is turned in to be checked. When a ship goes into overhaul, all its ammunition, including serviceable missiles, will be off-loaded at an NWS. Only a small amount of small arms ammunition will be retained on board.

After a serviceable missile is received at the NWS, it is moved to a rework/repair shop. (See figure 14-1.) The missile is disassembled and given a complete (inside and out) inspection. Modifications and update alterations are installed and all surfaces are cleaned and preserved. The missile is reassembled, tested, and recertified for fleet use. It is moved to RFI stowage or immediately reissued to a fleet unit. Essentially, the missile undergoes its own overhaul and remains within the Navy's ammunition inventory. That is a cost-effective and time-saving arrangement.

If a missile is damaged or suspected of being damaged, it must be turned in to an NWS. That should be done as soon as possible. For deployed units, it may mean transferring the missile to an AE-type ship first. The AE will return the round to an NWS along with the combatant ship's damage report.

Missile damage can result from various causes. Examples include rough handling, wetdown (from a sprinkler system), excessive temperatures, or dud/misfire failures. The NWS accepts these "bad" rounds and conducts a very thorough investigation. If the damage is minor, the NWS makes the necessary repairs and readies the missile for reissue. Sometimes the damage is major and beyond the repair capabilities of the NWS. In that case, the affected section(s) are returned to an industrial repair facility for rework. If the repair cannot be done economically, the section(s) are disposed of according to current instructions.

In summary, naval weapons stations provide several valuable services to the ordnance community. They act as major stock points, injecting new weapons and munitions into the fleet while removing the old and unserviceable items. They also act as maintenance and repair facilities to provide the fleet with the best weapons and munitions possible. The NWS activities play an important role in contributing to the high state of fleet readiness.

CONTAINERS AND HANDLING EQUIPMENT

Guided missiles are sturdy, well-constructed machines. But, because of their size, weight, and bulk, they are not that easy to handle. Nor are missiles indestructible. Most missile damage is, unfortunately, a result of carelessness and poor handling practices.

To reduce the possibility of damage, missiles are shipped, stowed, and handled with special equipments. Approved containers and handling equipments provide maximum missile safety with minimum handling by personnel.

There are hundreds of different and specialized types of containers and handling equipments in the ordnance field. Many are designed for a single purpose or use and cannot be interchanged with comparable items. Certain equipments are found only at an NWS or aboard an AE-type ship. The equipments covered in this text represent those you need to know about at this point in your career. Essentially, they are the containers and handling equipments used to deliver missiles to a ship.

Containers

Missile containers are large rectangular aluminum boxes used for the shipment and stowage of missiles and (separate) boosters. Normally, combatant ships do not carry containers on board. Containers are under the cognizant control of the Navy Ships Parts Control Center (SPCC), Mechanicsburg, Pa. They are maintained by the NWSs and AE-type ships.

Missile containers are identified by a mark and mod number. Become familiar with these numbers. You may also hear containers referred to as canisters, cans, or coffins. We will discuss the following containers:

1. Mk 199 container—Terrier-type missiles
2. Mk 200 container—Terrier-type boosters
3. Mk 372 container—Tartar-type missiles
4. Mk 632 container—Harpoon missiles
5. Mk 183 container—ASROC missiles

MK 199 CONTAINER.—The Mk 199 Mods 0 and 1 containers are designed to handle BT, HT, HTR, and Standard ER missiles. The Mod 0 container (figure 14-2) consists of a removable top, or lid, and an aluminum base. The lid is secured to the base by trunk-type latches. It also has lifting handles and stacking lugs. The lugs fit into cutouts or recesses in the base of another Mk 199 container. This arrangement permits stacked containers to be locked together. (Usually three high is the allowed limit.)

The base is mounted on four steel skids (located on the corners). Eyebolts may be secured to the skids to permit sling (crane) hoisting. Three forklift channels are available for forklift truck handling. Two lifting eyes (or holes) are provided in each end of the container's base. They are used when the container is manually positioned/moved with handlift trucks.

The missile is afforded some shock protection by various shear mounts, friction dampers, and polyurethane cushions. Tie rods snap into holes in the handling band guides. That secures/locks the handling bands (and missile) in place. A gasket provides an airtight seal when the lid is secured to the base.

Various accessories are on the outside of the container. Air breather or relief valves should be opened to permit air pressure equalization before the lid is removed. A record receptacle or pouch holds the missile's service record and other shipping documents. A desiccant cover permits small bags of desiccant to be placed (or replaced) into a basket without your opening the lid. A humidity indicator is mounted on the desiccant basket cover.

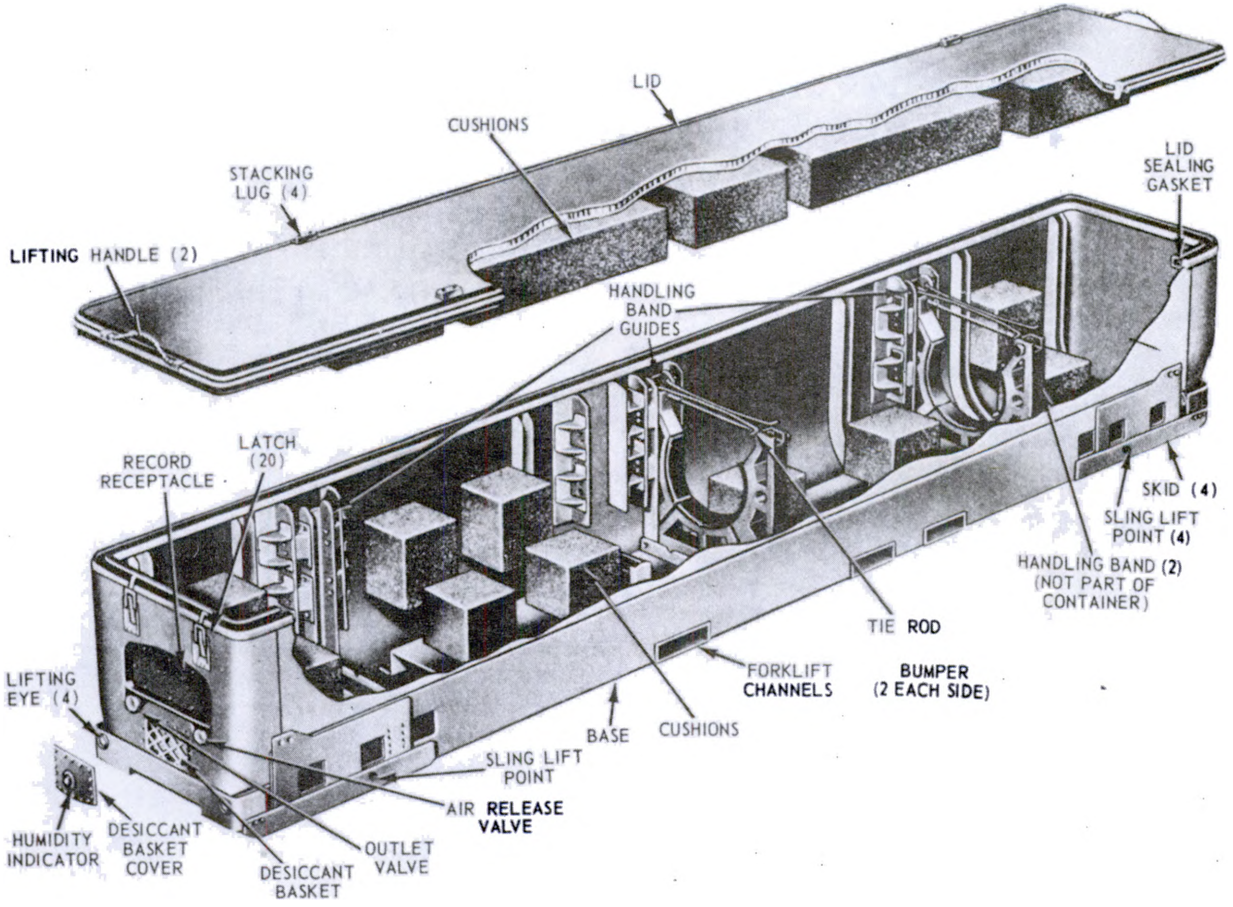

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Figure 14-2.—Mk 199 Mod 0 container for Terrier and Standard ER missiles.

The Mod 1 container has strengthened forklift channels and side plates (bumpers). These improvements reduce channel breakage and help prevent puncturing the container sides. An improved humidity indicator is also provided.

MK 200 CONTAINER.—The Mk 200 Mods 0 and 1 containers are used to ship and store Mk 12 and Mk 70 boosters. (Refer to figure 14-3.) To accommodate a booster, the Mk 200 booster container is slightly larger than the Mk 199 missile container. Otherwise, the two containers are quite similar.

Associated with a booster container is the Mk 205 Mod 0 (fin) container (figure 14-4). It is used to ship and store two booster fins. The outer metal container is reusable and is normally hand-carried aboard ship to the missile house. The fins are packed in two disposable corrugated fiberboard inner cartons.

MK 372 CONTAINER.—The Mk 372 container is available in six different mods, 0 through 5. The container is used to ship and store Tartar and Standard MR missiles. The Mods 0 and 1 containers handle IT and ITR missiles. The Mods 2 and 3 containers accept IT, ITR, and Standard MR missiles. The Mod 4 container has a modified suspension system to handle Standard ARM missiles. The Mod 5 container is an

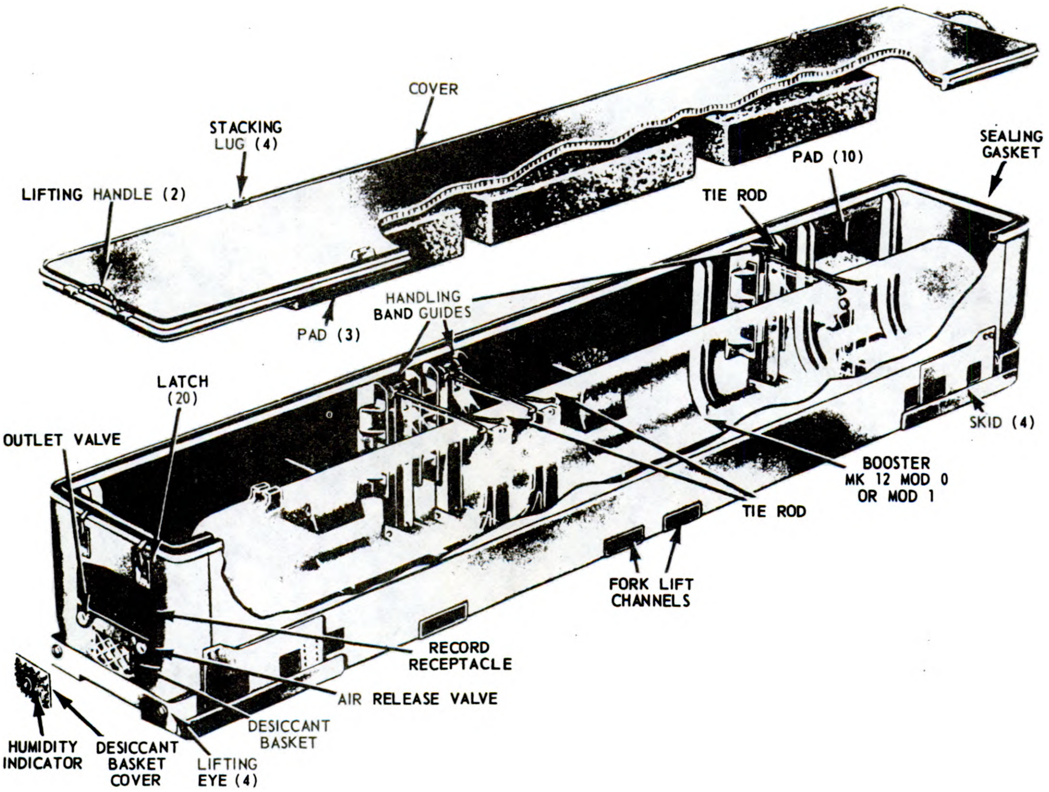

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Figure 14-3.—Mk 200 Mod 0 container for Mk 12 boosters.

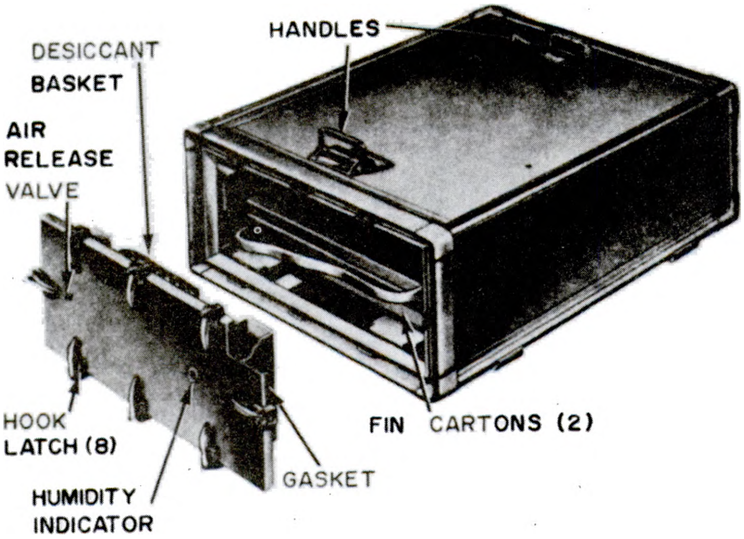

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Figure 14-4.—Mk 205 Mod 0 booster fin container.

improved version of a Mod 3 container. It accepts the same missiles and is shown in figure 14-5.

The bottom section of the container has an inner support (base) assembly. It is shock-mounted to the outer base assembly. A missile is secured to the inner assembly with its lower forward and aft launching shoes. A center missile support (U-frame) is installed over the upper forward launching shoe. It provides a downward force on the shoe and helps secure the missile. A clamping lever (or humping fork) is located below

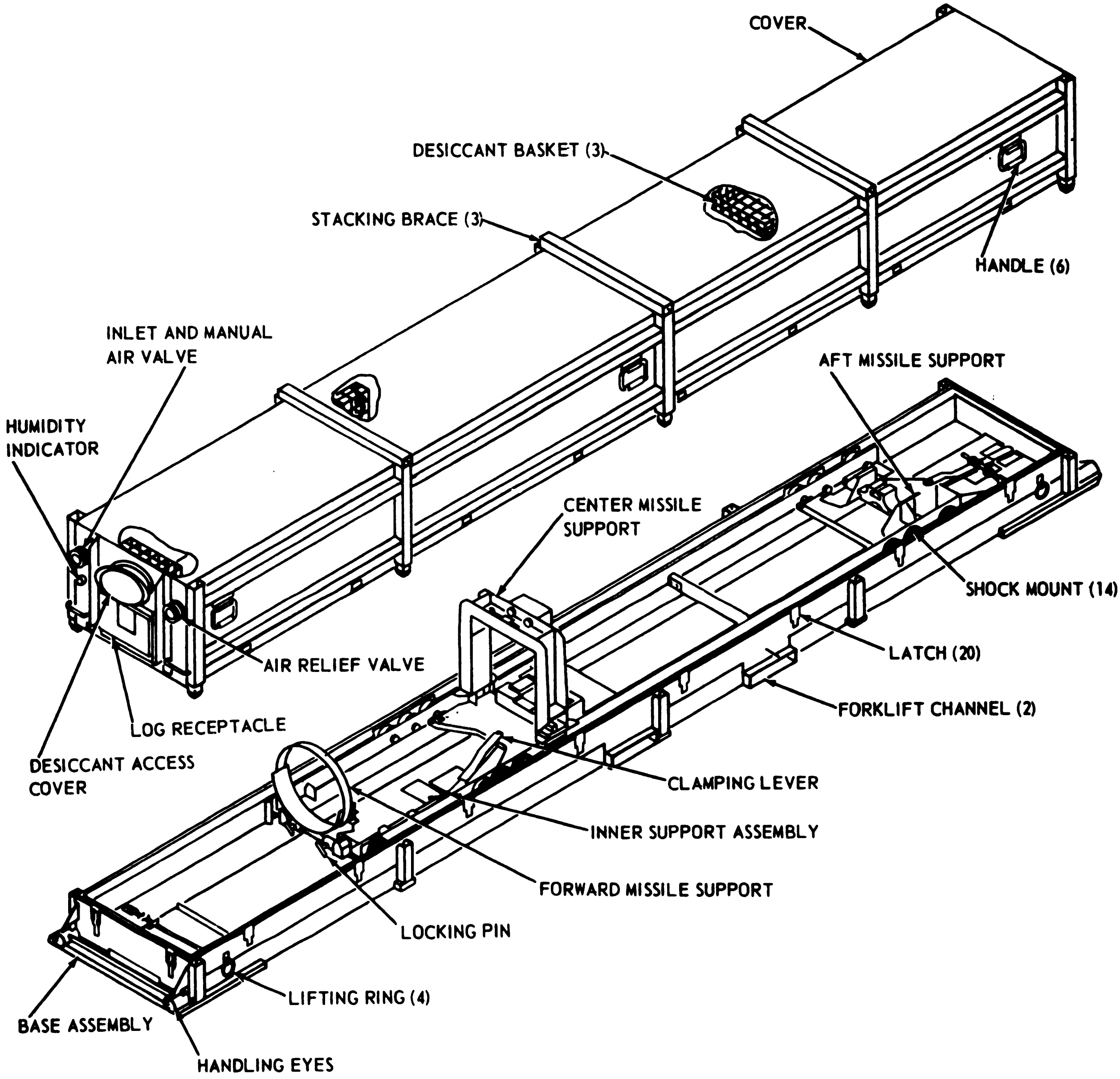

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Figure 14-5.—Mk 372 Mod 5 container for Tartar and Standard MR missiles.

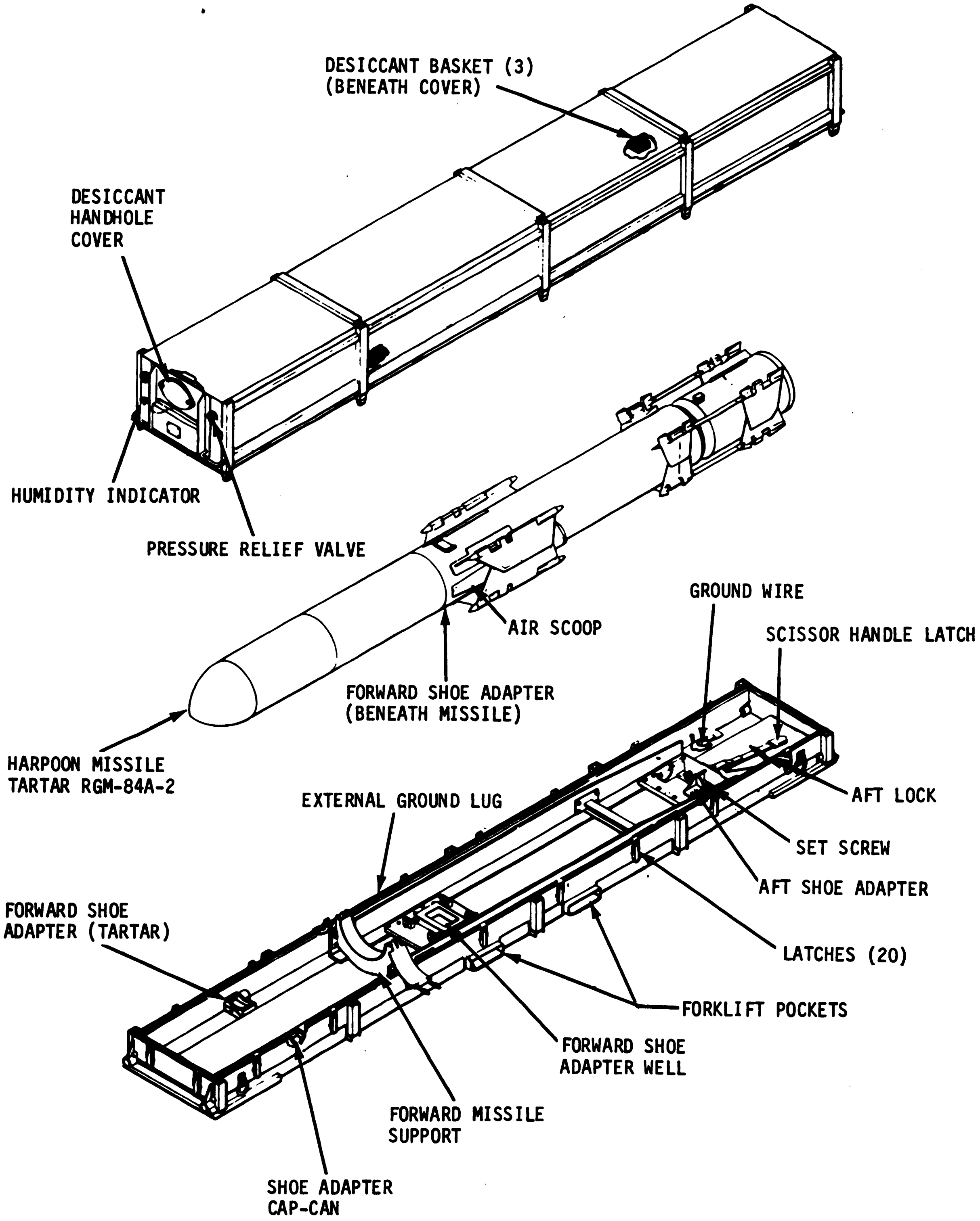

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Figure 14-6.—Mk 632 Mod 0 container for Tartar-launched Harpoon missiles.

the center missile support. It also aids in securing and prevents the missile from sliding forward.

The rectangular top cover is secured to the base by suitcase-type latches. The cover has a log receptacle, a desiccant access cover, and two air relief (breather) valves. More desiccant baskets are bolted to the inside of the cover. They are filled when the container is open. A humidity indicator is located on one end of the cover.

The Mk 372 container may be lifted by sling, forklift truck, or handlift trucks. The sling attaches to four lifting rings at the corners of the base. Two forklift channels are provided in the center of the base for forklift truck tines. Four handling eyes (two on each end of the base) permit handlift truck handling.

MK 632 CONTAINER.—The Mk 632 Mod 0 container (figure 14-6) is used to ship and store Tartar-launched Harpoon missiles. Physically and functionally it is somewhat similar to a Mk 372 container.

MK 183 CONTAINER.—The Mk 183 container is used to handle ASROC missiles. Figure 14-7 shows an external view of the container. Note the prominent extensions on the top cover. They accommodate the fins of the missile. This container may be handled by sling, forklift truck, and handlift trucks, too.

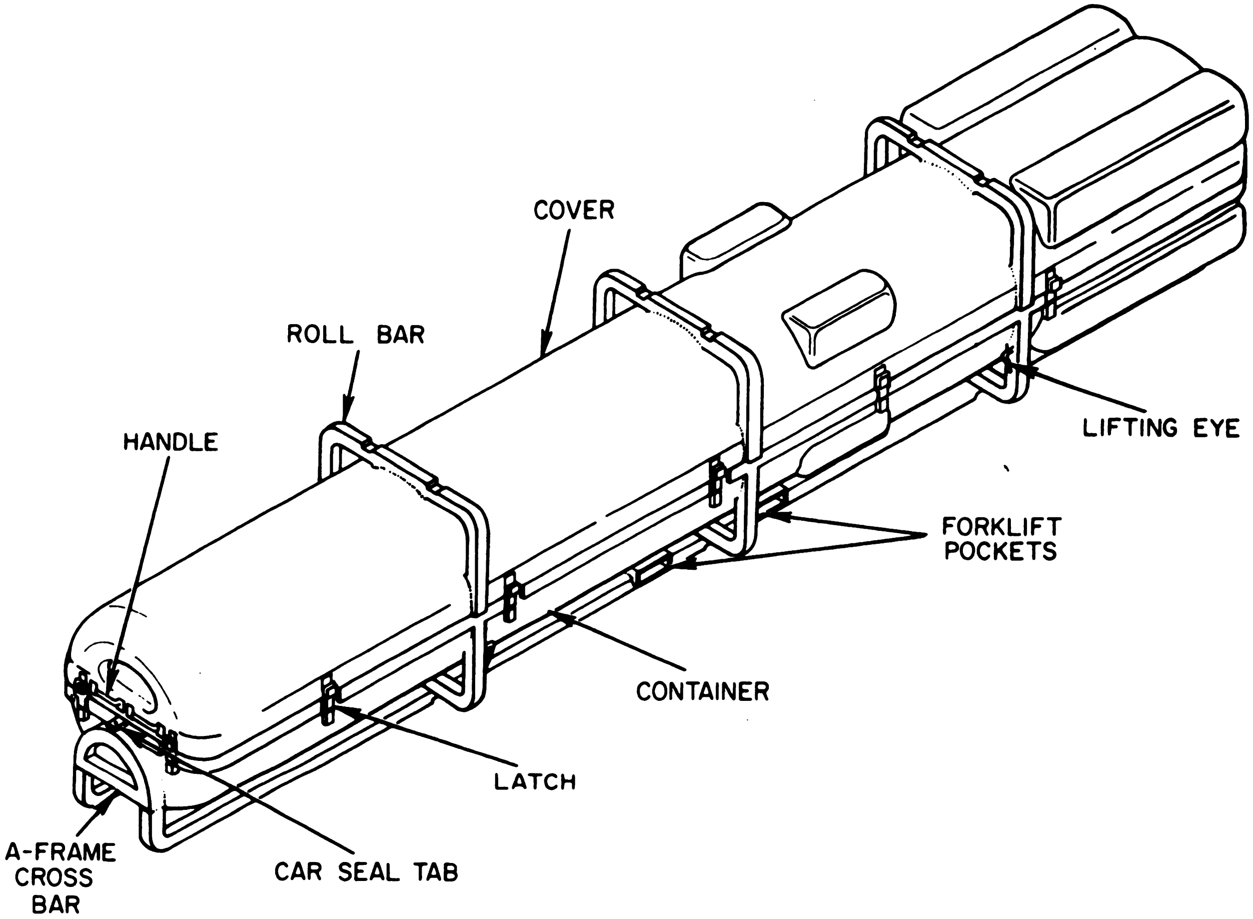

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Figure 14-7.—Mk 183 container for ASROC missiles.

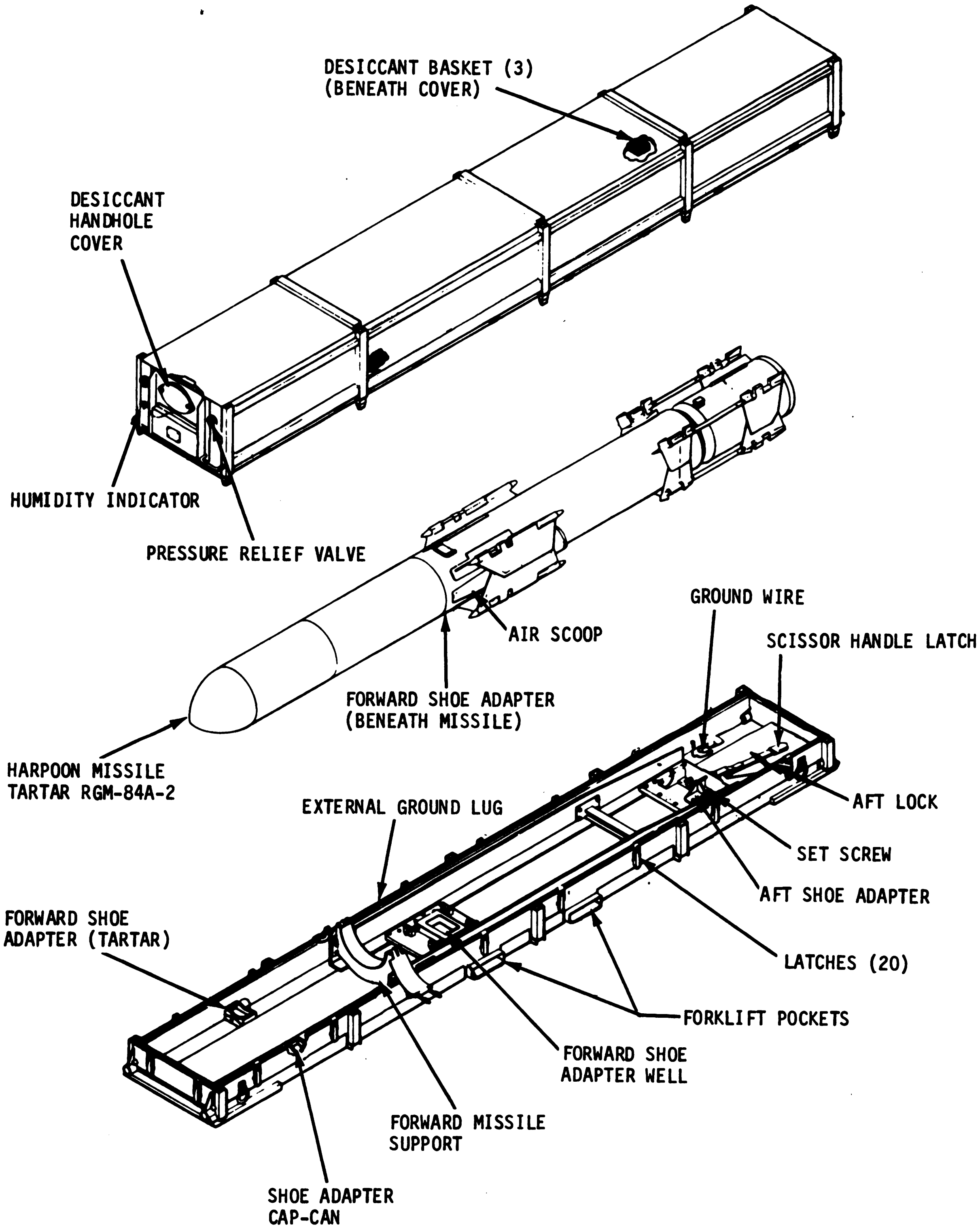

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Figure 14-6.—Mk 632 Mod 0 container for Tartar-launched Harpoon missiles.

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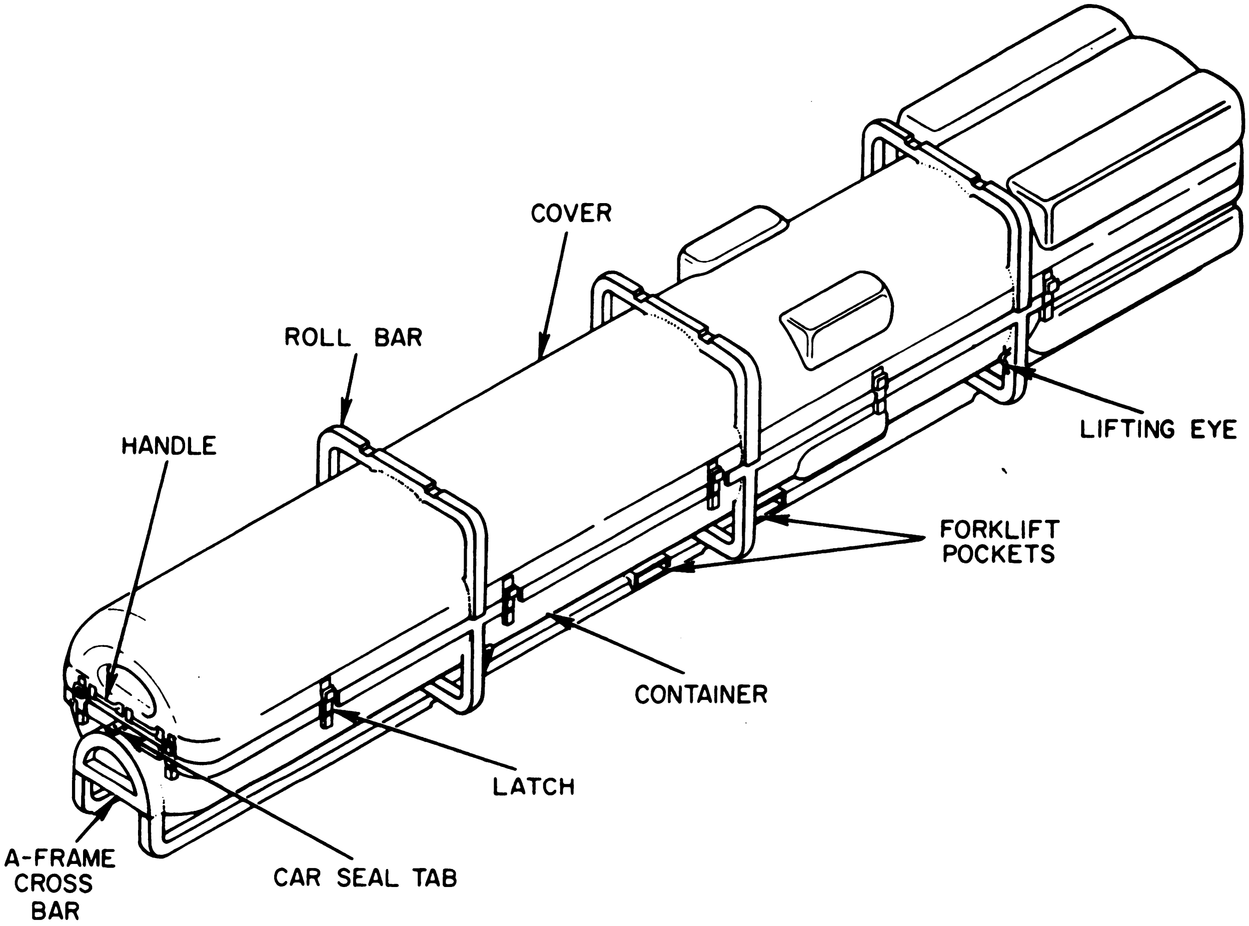

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Figure 14-7.—Mk 183 container for ASROC missiles.

Handling Equipments

We will limit our discussion of the many types of handling equipments to the following items:

1. Mk 79 and Mk 81 handling bands
2. Mk 6 missile transfer dolly
3. Mk 100 guided missile stowage adapter
4. Mk 20 stowage cradle
5. Hoisting beams—two types
6. Mk 8 dolly loading stand
7. Mk 45 handlift truck
8. Forklift trucks; general purpose

As you will soon see, these equipments are very versatile and, in many cases, multipurpose. Certain items are adaptable for handling any type of SMS missile. Each item listed above can be used at sea and ashore.

Be aware that there are numerous regulations governing the safe use of ordnance handling equipment. Any gear used to lift ammunition and explosives must be subjected to rigorous maintenance, inspection, and testing requirements. Equipments that have satisfactorily passed specified weight load tests will be marked to indicate safe working load limits and certification dates. Further details and guidance concerning handling equipment testing and certification are found in *Ammunition Afloat,* NAVSEA OP 4, and *Ammunition Ashore,* NAVSEA OP 5.

HANDLING BANDS.—The Mk 79 and Mk 81 handling bands were briefly described in chapter 3. (Refer to the "Mk 10 GMLS Strikedown" section and figure 3-10.) Figure 14-8

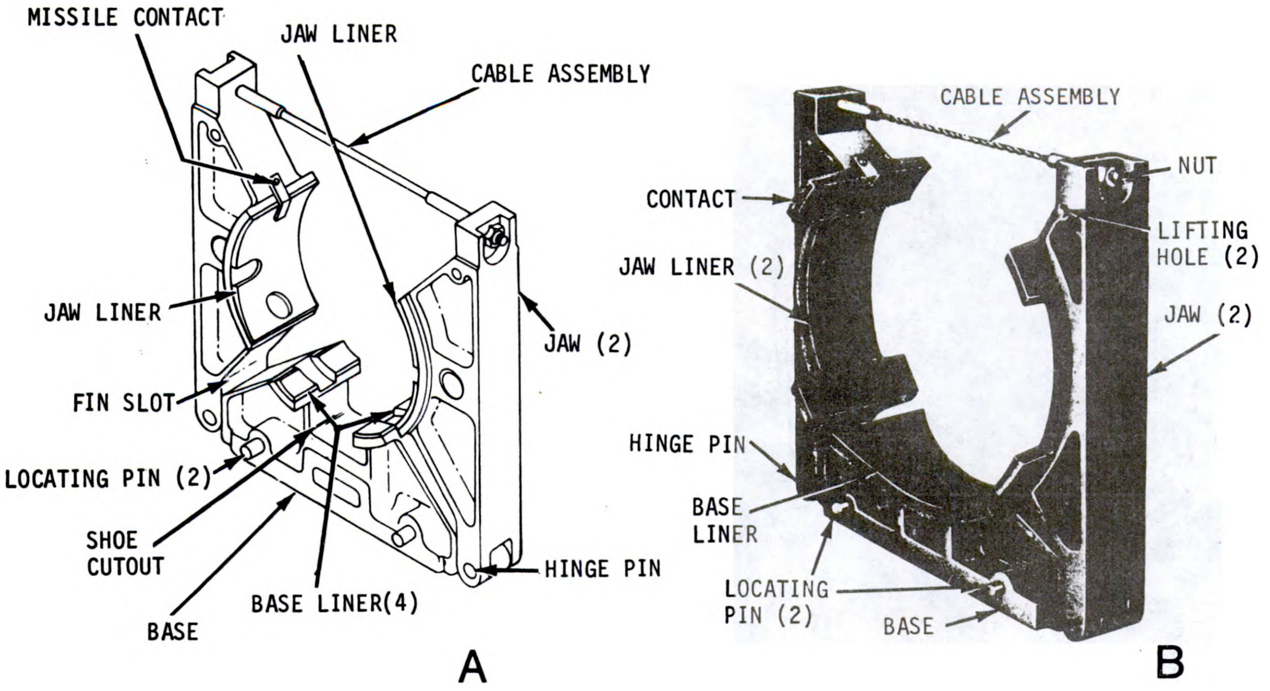

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Figure 14-8.—View A—the Mk 79 Mod 1 missile handling band; View B—the Mk 81 Mod 0 booster handling band.

shows both bands in greater detail. Note the differences between them.

The Mk 79 Mod 1 missile handling band (view A) can be used on all Terrier, Tartar, and Standard missiles. The band has a base, two hinged jaws, and a locking cable. The center of the base (the lower jaw) has a cutout area. This cutout accepts the lower forward and aft launching shoes of the Tartar and Standard MR missiles.

After the locking cable is disconnected, the jaws can be opened. The band is installed on the missile and the locking cable is secured again. The missile's dorsal fins fit within the areas designated as fin slots or fin cutouts.

The Mk 81 Mod 0 booster handling band (view B) is used on all Terrier and Standard ER boosters. The booster band is physically and functionally similar to the Mk 79 missile band. However, the two bands are not interchangeable. The Mk 81 band is slightly larger to accommodate a booster's greater diameter. Also, the base's jaw section does not have a shoe cutout.

Handling bands have several purposes. They are necessary for all Terrier and Standard ER handling operations. The bands support and secure these rounds in their shipping containers and to a transfer dolly. They also connect the rounds to the Mk 10 GMLS's strikedown elevator and transfer car.

MISSILE TRANSFER DOLLY.—The Mk 6 missile transfer dolly is used to transport rounds between supplying and receiving activities. Two versions of the dolly were briefly described in chapter 3. (Refer to figures 3-11 and 3-18.) At that time, we simply identified them as the Terrier and Tartar transfer dollies respectively. You will also hear them called "grasshoppers."

Figure 14-9 shows both Mk 6 dollies in greater detail. The Mk 6 Mods 1 and 3 dollies (view A) are used with Terrier and Standard ER missiles and boosters. These rounds are secured to and suspended from the dolly's inner framework by their handling bands.

The Mk 6 Mods 2 and 4 dollies (view B) are used with Tartar, Standard MR, and Harpoon missiles. The Mk 6 dolly incorporates a length of guide rail and an adapter assembly. The guide rail, secured to the dolly's inner framework, is identical to any Tartar GMLS guide rail. A center track or slot accepts a Mk 11 GMLS's rammer or a Mk 13 and 22 GMLSs' strikedown chain. Forward and aft shoe tracks guide and support the missile by its upper launching shoes. Two openings are cut into the guide rail tracks. These openings permit the missile's shoes to be engaged to or disengaged from the dolly's guide rail.

The Tartar adapter assembly is mounted to the forward end of the dolly's framework. In its raised position (as seen in view B of figure 14-9), the adapter can connect to the rear of a guide arm. Remember the ball-and-hitch arrangement described in chapter 3? (See figure 3-20.) When the dolly is not in use, the adapter's braces (arms) can be unpinned. The assembly is then folded to the rear and locked down. With the adapter folded, empty transfer dollies can be stacked on one another. Sometimes the adapter is referred to as a "gooseneck."

Aside from these major differences, Terrier and Tartar Mk 6 dollies are very similar. The framework consists of welded tubular hardened alloy steel. Four shock-mounted wheel assemblies have manually operated caster locks. The wheels are unlocked whenever the dolly is to be moved from one area to another. Unlocked, the wheels can turn 360° in either direction (similar to the front wheels on a supermarket shopping cart). That eases dolly movement around corners and in tight, limited deck-space areas. The wheels are locked when the dolly is aligned to a guide arm or is over a strikedown hatch. The wheels can be locked only when they are at 0° or 180°. The dolly can still be rolled, but only in a straight line (forward or backward).

The dolly has a hydraulically actuated disc-brake system. The brakes are controlled by a manually operated deadman-type brake handle. The handle must be pumped a few times (which builds up hydraulic pressure) to release the brakes. If you are the brakeman on a dolly, please be careful. Releasing the brake handle automatically

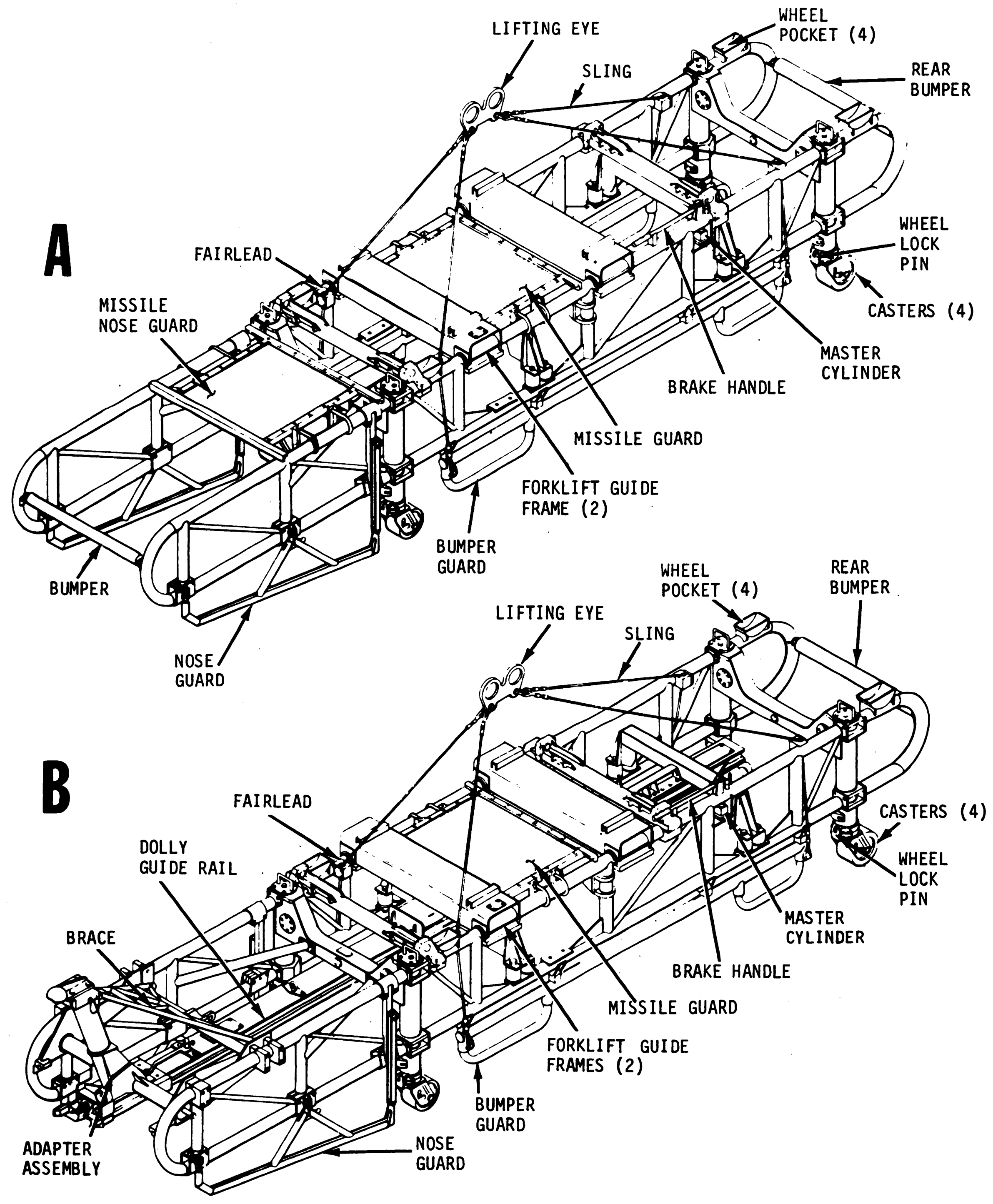

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Figure 14-9.—Mk 6 missile transfer dolly: A. Mods 1 and 3 for Terrier and Standard (ER) missiles and boosters; B. Mods 2 and 4 for Tartar, Standard (MR), and Harpoon missiles.

sets the brakes and Mk 6 dollies will "stop on a dime"! This action not only "surprises" your shipmates, but jars/jolts the missile quite a bit. Release the handle slowly to stop slowly.

A four-legged sling provides a means to hoist the dolly by crane. The sling also actuates the hinged side-mounted bumper guards that protect the center of the missile. Nose guards and a rear bumper provide additional protection. Clear plastic guards keep an unused sling from hitting the missile.

Two forklift guide frames, or channels, are installed on the dolly. Wheel pockets on the top framework permit empty dollies to be stacked in stowage. Loaded dollies must not be stacked.

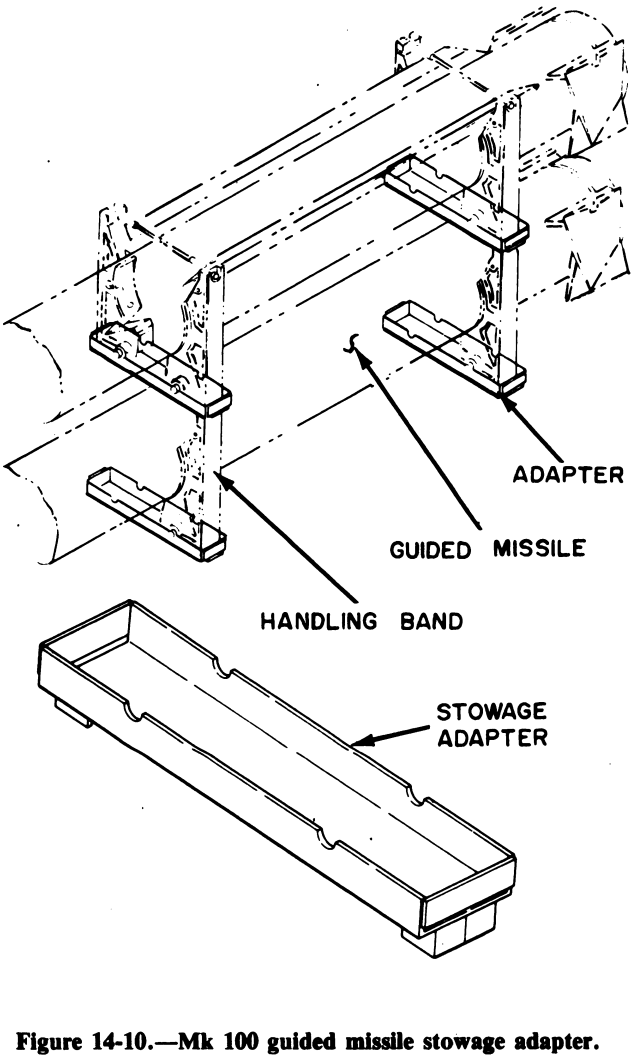

Figure 14-10.—Mk 100 guided missile stowage adapter.

Also, never leave a missile in a dolly any longer than necessary. One other word of warning—watch your toes! Transfer dollies are heavy, cumbersome vehicles. If one runs over your foot, you WILL understand the true meaning of pain.

GUIDED MISSILE STOWAGE ADAPTER.—The Mk 100 guided missile stowage adapter is shown in figure 14-10. It is a simple aluminum alloy weldment that fits along the top and bottom of a handling band. The adapter adds support to the bands when missiles/boosters are stacked as shown in the figure. The Mk 100 stowage adapter is normally used when Mk 20 stowage cradles are not available.

STOWAGE CRADLE.—The Mk 20 stowage cradle is shown in figure 14-11. It is a welded aluminum frame with four lifting eyes and two forklift pockets. Three cradle guides accept and lock the Mk 79 or Mk 81 handling bands in place. Stacking pockets are provided on the bottom of the cradle's side rails (frame).

Figure 14-12 illustrates various missile and booster stacking arrangements using a Mk 20 cradle. (Three rounds high is the limit.) The cradle can also be used to load/unload a Mk 6 transfer dolly if a forklift truck is available.

HOISTING BEAMS.—Figure 14-13 shows two common hoisting beams. These devices are often called handling beams or strongbacks. Generally, a hoisting beam attaches to a round's shoes or to its handling bands. The round can then be lifted out of its shipping container by a forklift, truck, or crane. The missile or booster is then transferred to a Mk 20 stowage cradle or a dolly loading stand. Of course, this sequence can be reversed to reload a container.

The Mk 5 hoisting beam (view A) handles Tartar and Standard MR missiles. It is manually connected to the shoes of the missile. The two shoe clamps slide over the upper shoes of the round.

The Mk 15 hoisting beam (view B) can be adjusted to handle all rounds. Instead of clamping to the missile/booster shoes, it attaches to the Mk 79 and Mk 81 handling bands. The adapters and

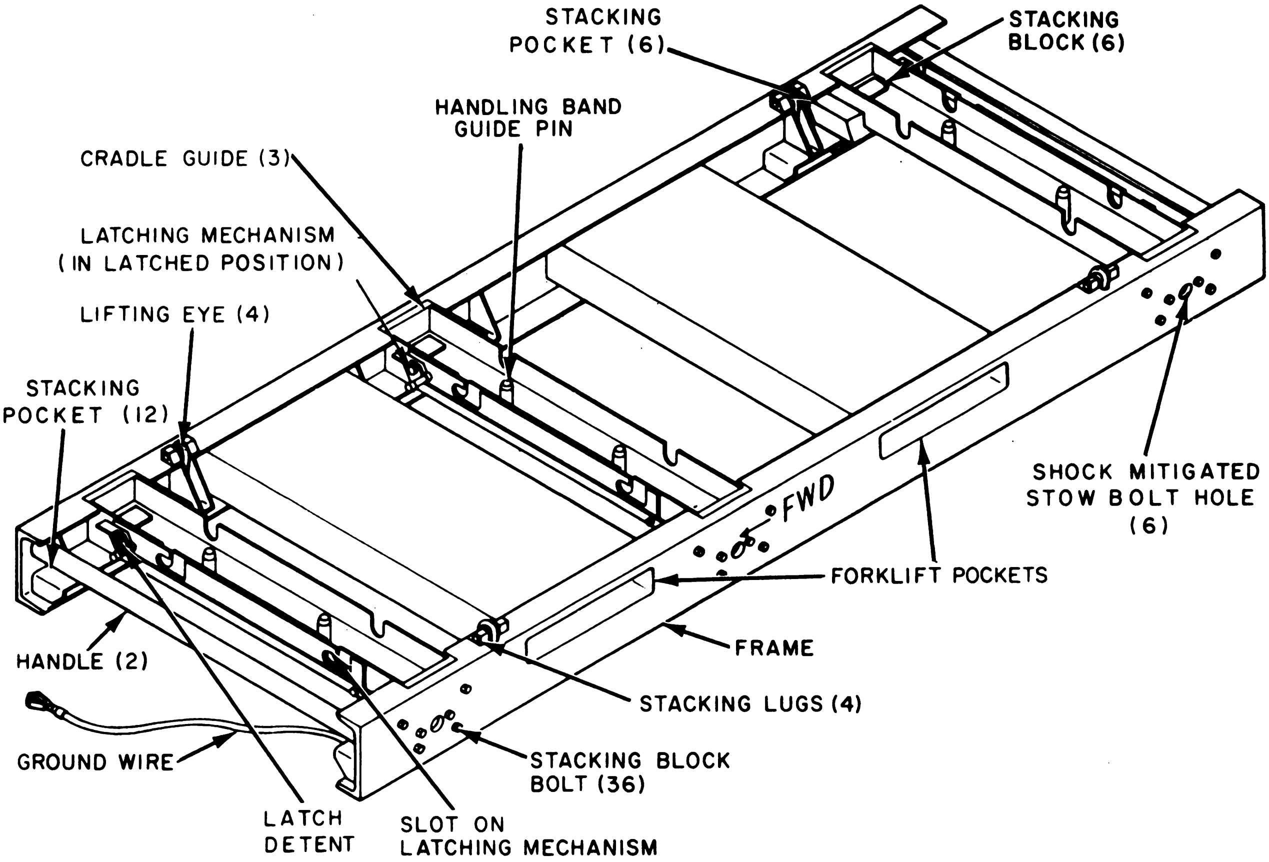

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Figure 14-11.—Mk 20 stowage cradle.

cross-arm assemblies can be adjusted to different load lengths. The lifting plate assembly can also be moved to obtain the correct center of gravity for different loads.

DOLLY LOADING STAND.—The Mk 8 dolly loading stand is seen in figure 14-14. It is adaptable to all Terrier, Tartar, and Standard missiles and boosters. The stand is used to load/unload a Mk 6 transfer dolly. You might also hear the Mk 8 loading stand called a roll stand or (simply) a load stand.

The stand is a braced, tubular aluminum frame. Two roll ring assemblies are mounted near the ends of the frame. Each ring assembly consists of two separate and removable sections or halves. A ring-locking mechanism is part of each roll ring assembly. Normally, the locking mechanism is engaged and prevents the ring assembly from rotating. Depressing a foot pedal (not shown in the figure) disengages the lock mechanism. The roll ring assembly is then free to be turned. The frame also mounts three pairs of handling band saddles and has a pair of forklift truck pockets.

To handle Terrier and Standard ER rounds, the two roll ring assemblies must be removed completely. The top halves of the rings are unlocked and lifted from their bottom halves. The two foot pedals are depressed and the lower ring halves are rotated manually. They are turned until they disengage from the stand and can be removed. The Mk 79 or Mk 81 handling bands may then be secured to their saddles.

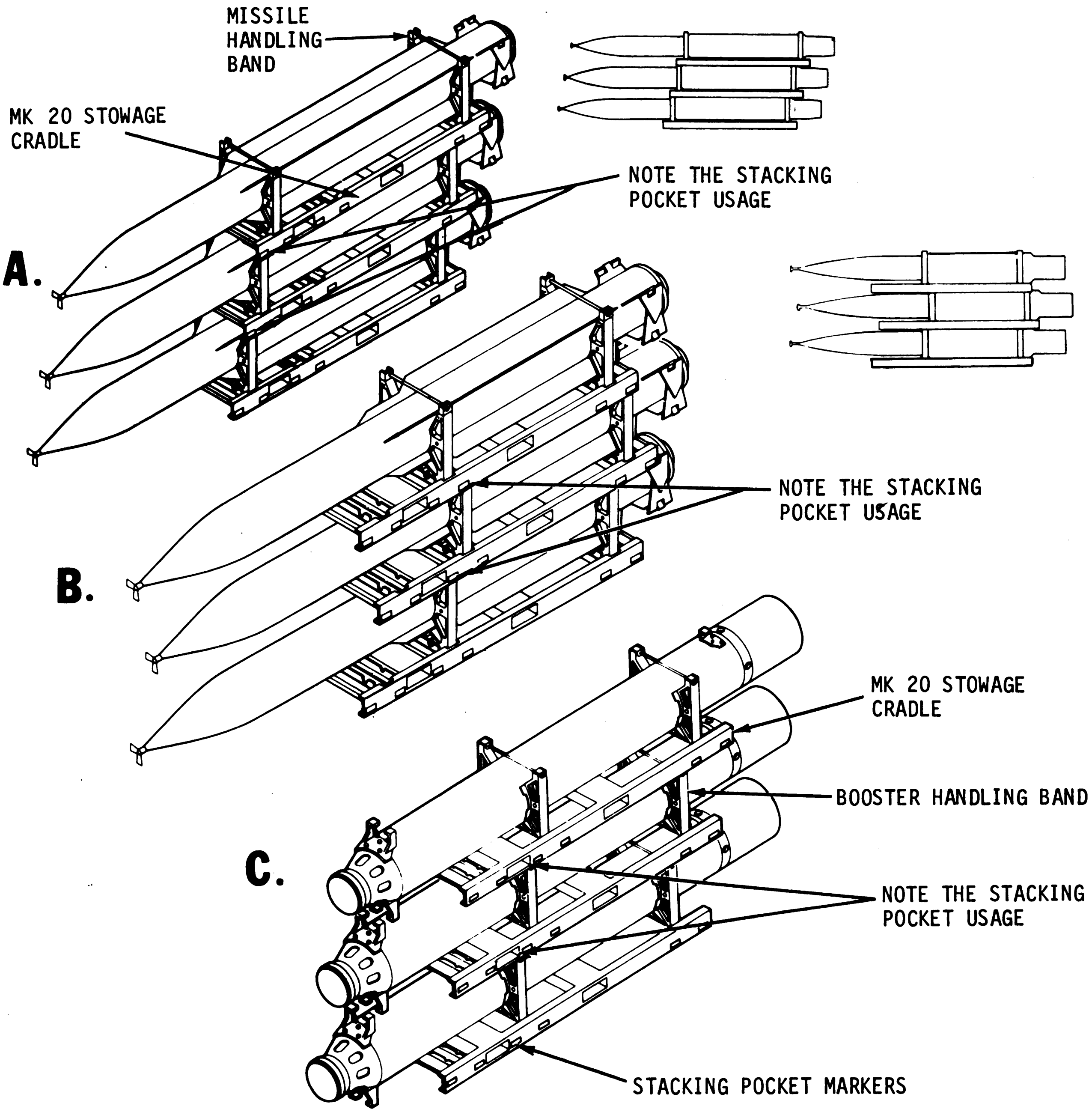

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Figure 14-12.—Stacking configurations available with the Mk 20 stowage cradle: A. Staggered-aft method; B. Alternate staggering method; C. Booster stacking (mandatory) method.

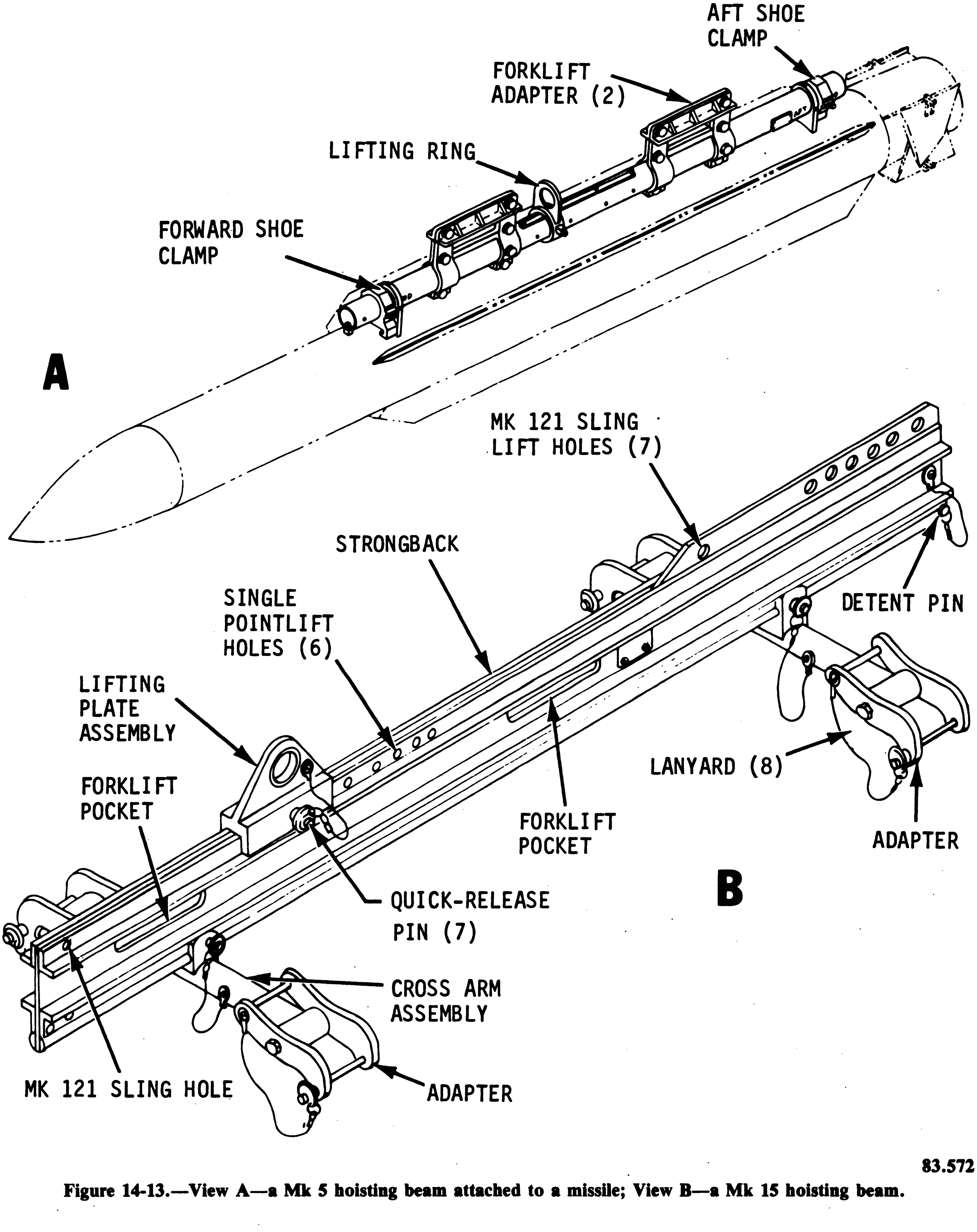

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Figure 14-13.—View A—a Mk 5 hoisting beam attached to a missile; View B—a Mk 15 hoisting beam.

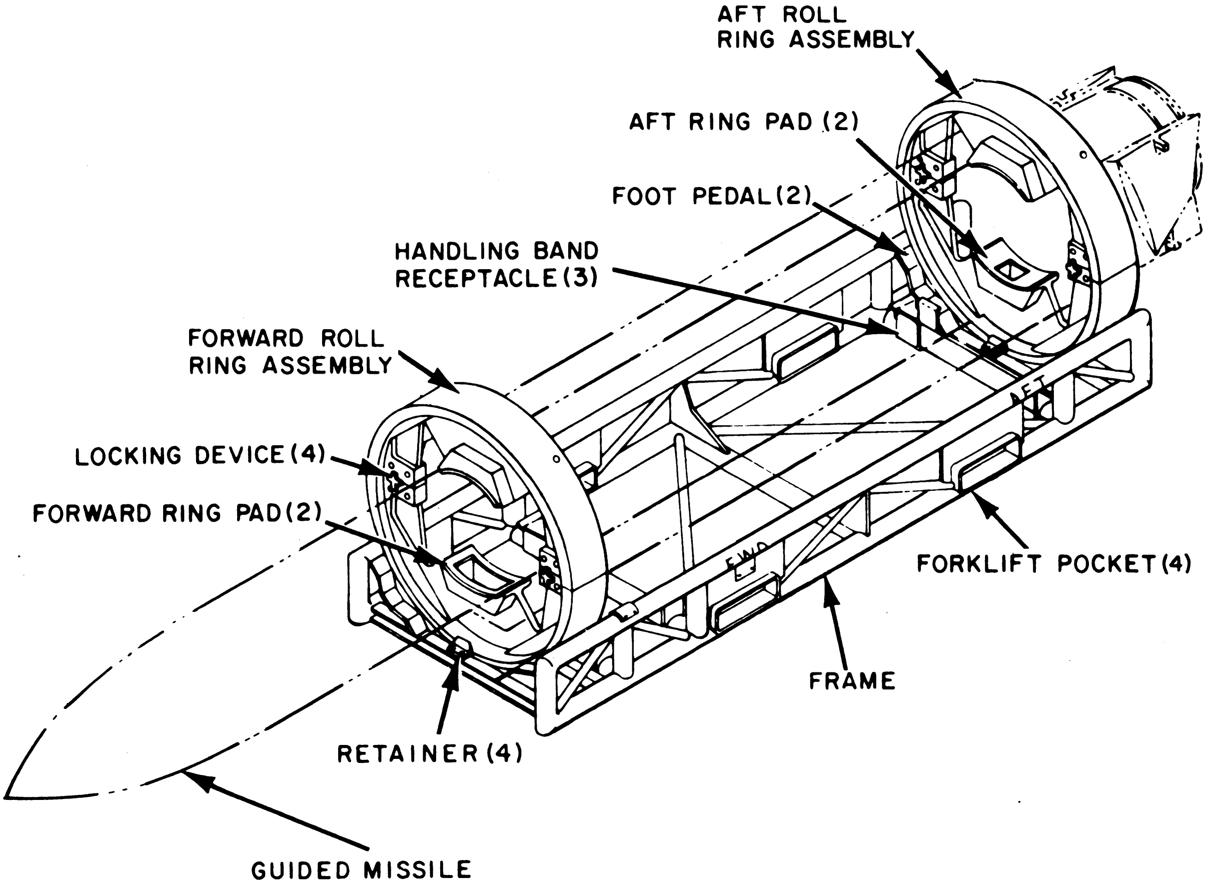

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Figure 14-14.—Mk 8 dolly loading stand.

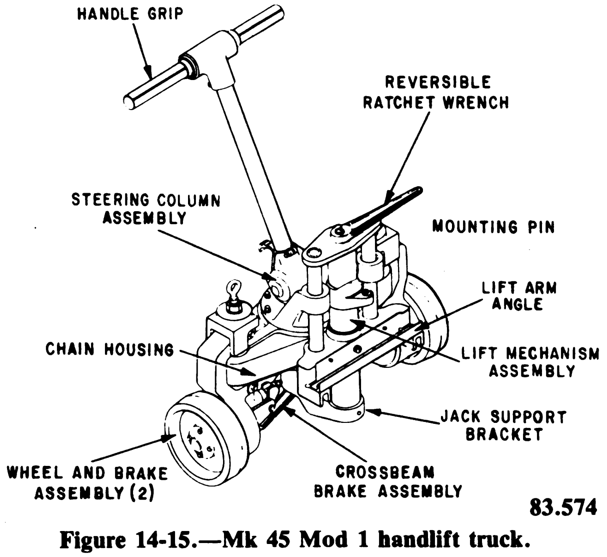

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Figure 14-15.—Mk 45 Mod 1 handlift truck.

To handle Tartar and Standard MR missiles, only the top roll ring halves must be removed. The forward and aft missile shoes are guided into and supported by shoe pockets in the lower ring halves. Handling bands are not required in this type of handling operation.

The stand also provides a means to rotate Tartar and Standard MR missiles. Once a missile is loaded into the lower ring halves, the top ring halves are reinstalled and clamped. Depressing the foot pedals unlocks the roll ring assemblies and the missile can be rotated/rolled. This action is necessary to orient a missile for B-arm loading on a Mk 11 GMLS, for example. A missile may be rolled to ease minor maintenance actions also.

HANDLIFT TRUCKS.—The Mk 45 Mod 1 handlift truck is shown in figure 14-15. Two

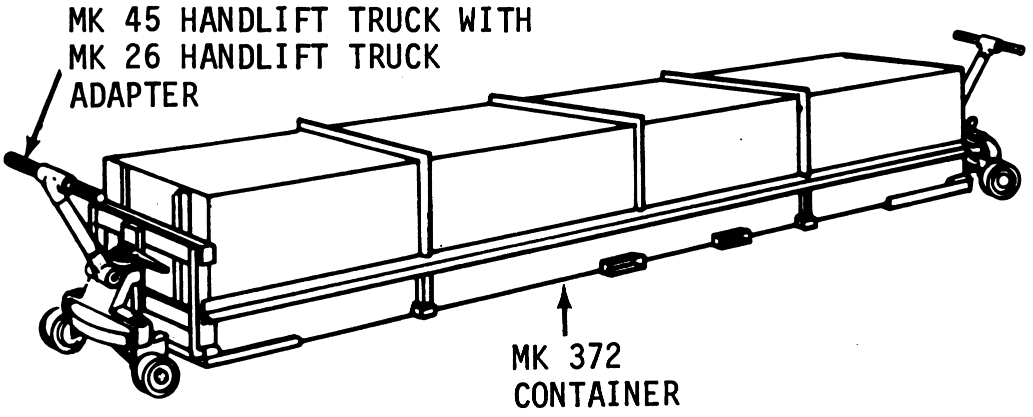

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Figure 14-16.—Handling a Mk 372 container with Mk 45 handlift trucks and Mk 26 handlift truck adapters.

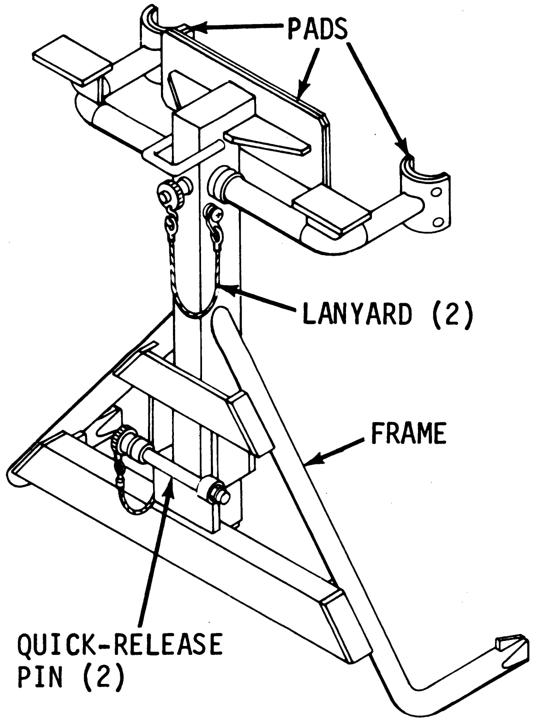

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Figure 14-17.—Mk 26 Mod 2 handlift truck adapter.

handlift trucks can be used to move loaded/unloaded shipping containers and stowage cradles. Figure 14-16 illustrates handling of a Mk 372 container. Two people must synchronize their efforts during steering maneuvers. They must also provide the "horsepower" to move the load.

The truck consists of an aluminum body, a steel steering post, and a lift mechanism. A reversible ratchet is operated to raise/lower the lift mechanism manually. The mechanism has a mounting pin and a lift-arm angle to engage the load.

The truck is guided by moving the steering post (or tow bar). Steering may be accomplished with the post in either a horizontal or "latched up" (near vertical) position. The wheel brakes must be released to permit steering. Each wheel has its own brake assembly. Both assemblies are controlled through a common linkage connected to the handle grips. The brakes release when the handle grips are rotated and held at their full forward position.

The lifting surface of the truck is its single lift-arm angle. The angle engages a bracket on a container, cradle, skid, or special adapter device. The mounting pin serves as a guide pin. It engages a recess on Mk 183 ASROC containers (only). The pin is not a lifting surface. The ratchet handle will raise/lower the lift arm about 8 inches.

A Mk 26 Mod 2 handlift truck adapter (figure 14-17) can be attached to the front of the Mk 45 handlift truck. The adapter makes the handlift truck compatible with various container loads. Pads prevent metal-to-metal contact between the adapter and a container. Two lower arms fit into the lifting or handling eyes of the various containers described earlier. The Mk 199, Mk 200, Mk 372, and Mk 632 containers can be moved using two handlift trucks with adapters.

FORKLIFT TRUCK.—A forklift truck (figure 14-18) is a mobile three- or four-wheel automotive unit. It enables one individual to pick up a load, transport, and lift it to various heights. The truck is designed on the cantilever principle. The load is counterbalanced by the weight of the truck in back of the center of the front wheels. The front wheels act as the fulcrum or center of balance.

The truck has a two-tine fork which is secured to the supporting frame. The tines can be moved vertically by a mechanical or hydraulic lift. They can also be tilted frontward and backward. This aids in picking up and balancing the load.

Forklift trucks used to handle ordnance may be powered by diesel engines or by a battery-powered electric motor. A mechanical or hydraulic braking system can be used. The steering system may be an automobile- or lever-type mechanism. Pneumatic tires are provided for use over rough and uneven terrains. They are also used in muddy or soft, sandy ground. Solid rubber, cushion-type tires are used over smooth and hard surfaces. These areas include paved

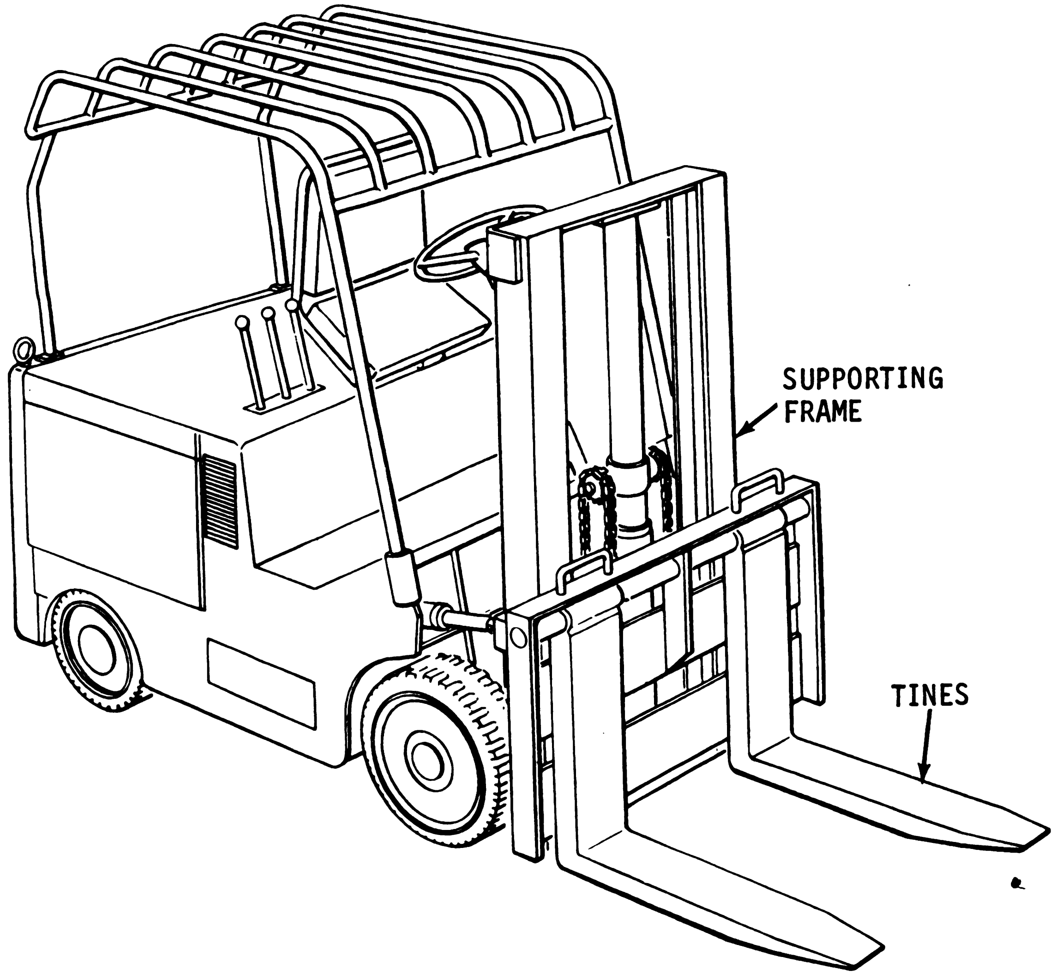

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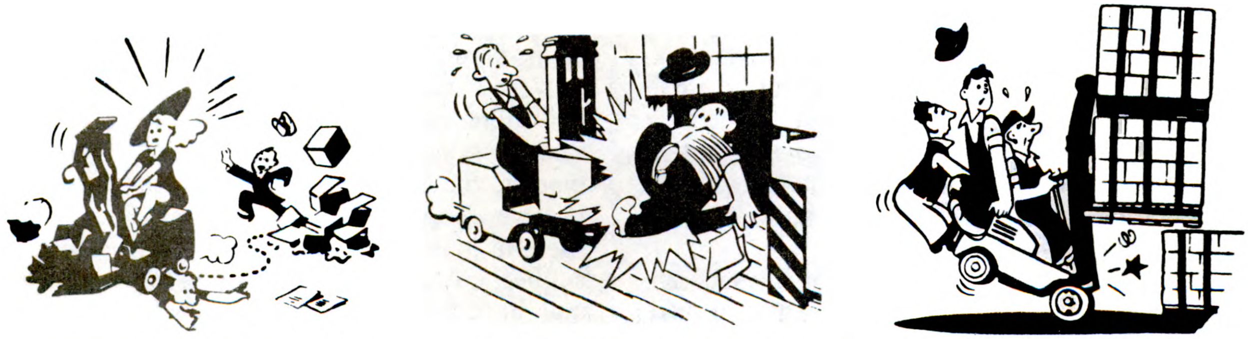
Figure 14-18.—Typical front-loading forklift truck.



NEVER PERMIT UNAUTHORIZED PERSONS TO OPERATE FORK TRUCKS.

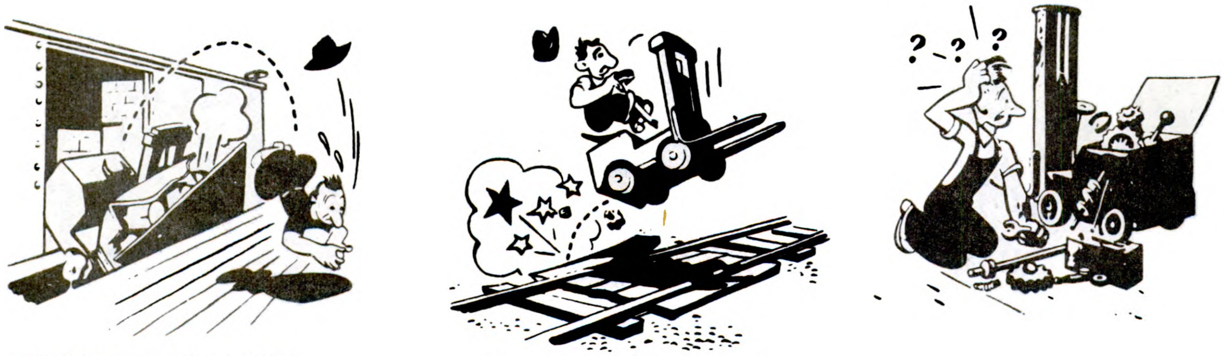
SOUND HORNS OR WARNING GONGS AT ALL BIND INTERSECTORS.

DON'T OVERLOAD YOUR TRUCK... LIGHTEN LOADS INSTEAD OF COUNTER WEIGHTING.

DON'T "COWBOY" YOUR TRUCK... REPAIRS ARE COSTLY.

NEVER TOW FREIGHT CARS WITH FORK TRUCKS... THEY'LL FINISH BY TOWING YOU.

RIDING ON FORK IS DANGEROUS... DON'T PERMIT IT ON YOUR TRUCK.



CHECK BRIDGE PLATES FREQUENTLY... BE SURE THEY'RE SECURE.

DRIVE S-L-O-W-L-Y OVER RAILROAD TRACKS AND ROUGH SURFACES.

DON'T ATTEMPT "MINOR" REPAIRS... CALL A QUALIFIED REPAIRMAN.

40.67(53C)B

Figure 14-19.—Some do's and don'ts of forklift truck operating!

Mk 372, and Mk 632 containers can be moved using two handlift trucks with adapters.

FORKLIFT TRUCK.—A forklift truck (figure 14-18) is a mobile three- or four-wheel automotive unit. It enables one individual to pick up a load, transport, and lift it to various heights. The truck is designed on the cantilever principle. The load is counterbalanced by the weight of the truck in back of the center of the front wheels. The front wheels act as the fulcrum or center of balance.

The truck has a two-tine fork which is secured to the supporting frame. The tines can be moved vertically by a mechanical or hydraulic lift. They can also be tilted frontward and backward. This aids in picking up and balancing the load.

Forklift trucks used to handle ordnance may be powered by diesel engines or by a battery-powered electric motor. A mechanical or hydraulic braking system can be used. The steering system may be an automobile- or lever-type mechanism. Pneumatic tires are provided for use over rough and uneven terrains. They are also used in muddy or soft, sandy ground. Solid rubber, cushion-type tires are used over smooth and hard surfaces. These areas include paved

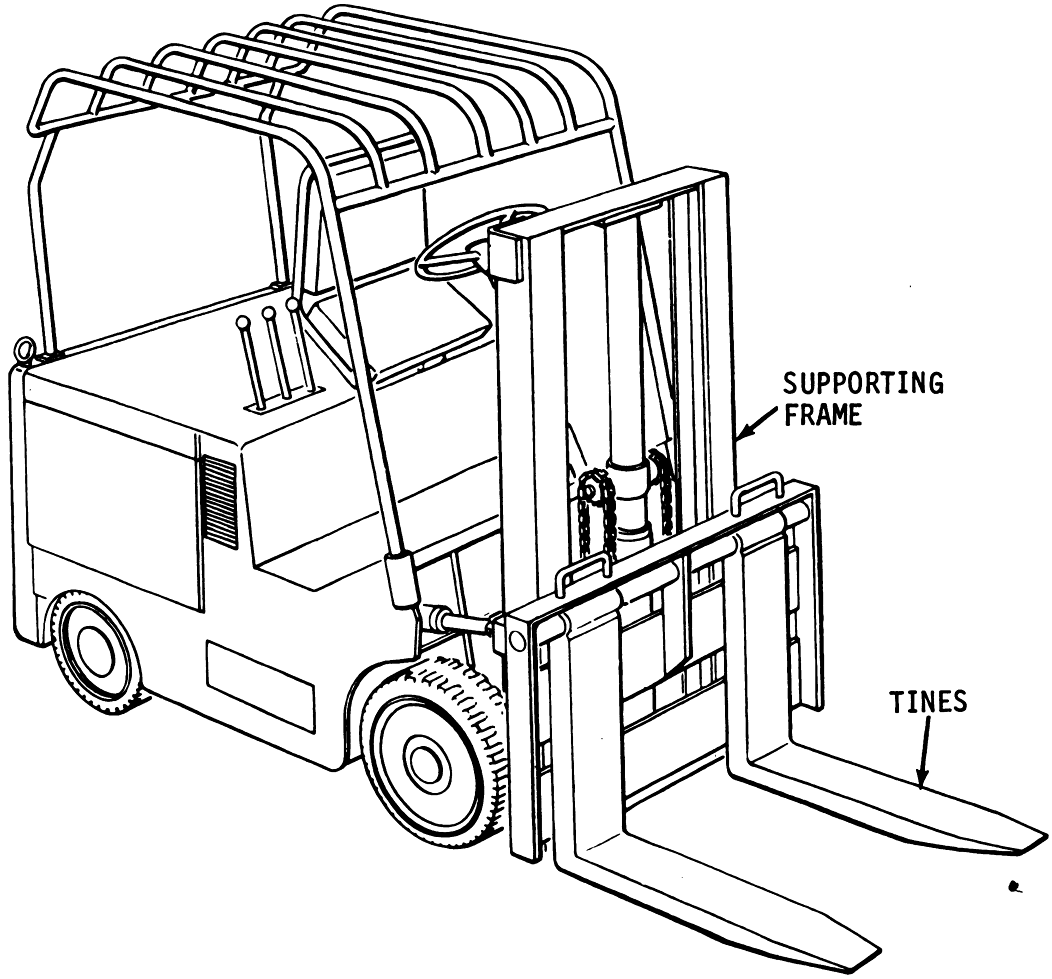


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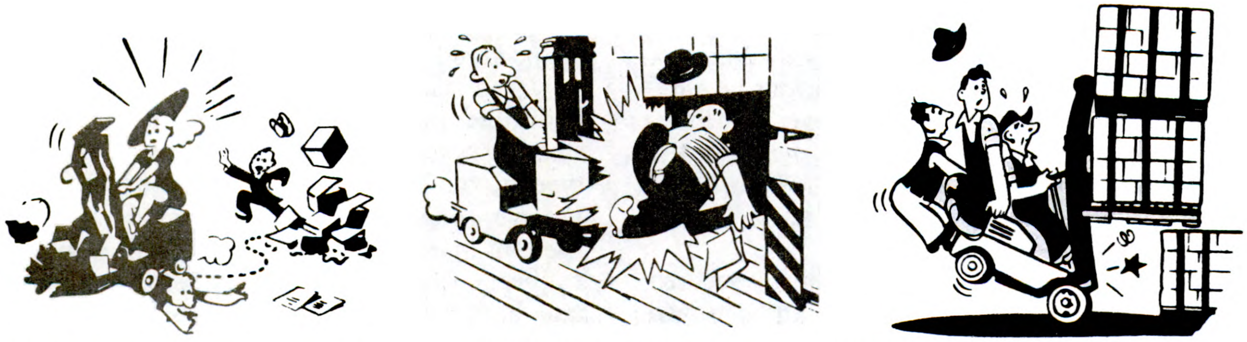
Figure 14-18.—Typical front-loading forklift truck.



NEVER PERMIT UNAUTHORIZED PERSONS TO OPERATE FORK TRUCKS.

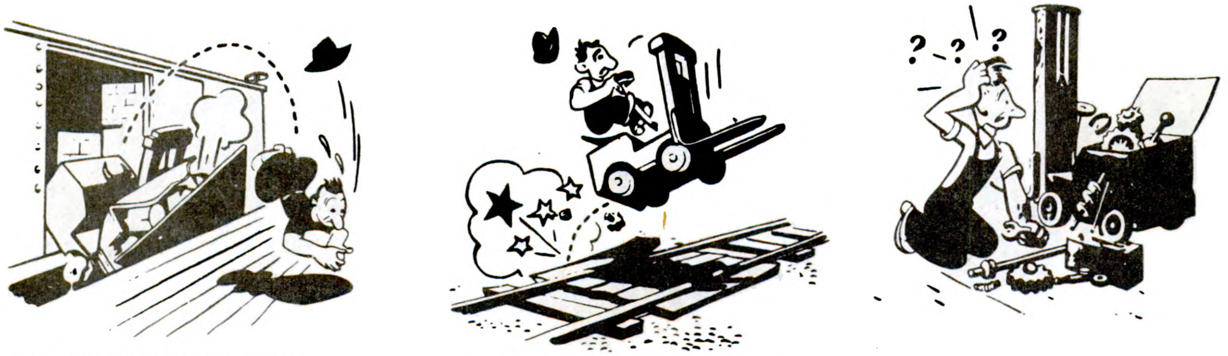
SOUND HORNS OR WARNING GONGS AT ALL BIND INTERSECTORS.

DON'T OVERLOAD YOUR TRUCK... LIGHTEN LOADS INSTEAD OF COUNTER WEIGHTING.

DON'T "COWBOY" YOUR TRUCK... REPAIRS ARE COSTLY.

NEVER TOW FREIGHT CARS WITH FORK TRUCKS... THEY'LL FINISH BY TOWING YOU.

RIDING ON FORK IS DANGEROUS... DON'T PERMIT IT ON YOUR TRUCK.



CHECK BRIDGE PLATES FREQUENTLY... BE SURE THEY'RE SECURE.

DRIVE S-L-O-W-L-Y OVER RAILROAD TRACKS AND ROUGH SURFACES.

DON'T ATTEMPT "MINOR" REPAIRS... CALL A QUALIFIED REPAIRMAN.

40.67(53C)B

Figure 14-19.—Some do's and don'ts of forklift truck operating!

roads, magazine and warehouse floors, and pier areas.

Battery-electric forklift trucks are either spark-enclosed or explosion-proofed. They provide safe operation in atmospheres with explosive mixtures of air and flammable gases, vapors, or dust. Spark-enclosed trucks ensure that no flame or sparks from arcing generators, motors, or switches escape to the atmosphere. Explosion-proof trucks are of a heavy steel, fully enclosed construction. They are designed to contain an internal explosion completely. Additionally, a constant flow of air is forced over the stowage batteries to dilute/diffuse any emitted battery gases. The exhaust systems of diesel-powered trucks have spark-arresting devices. This permits safe operation in areas where exhaust sparks could be a danger.

The capacity of a forklift truck is its most important characteristic. It governs the maximum weight of a load that can be counterbalanced safely. Other important characteristics include such items as maximum lift height, minimum turning radius, range of tilt, and travel speeds.

In missile-handling operations, a forklift truck is an extremely important and necessary piece of equipment. Only trained and qualified personnel are permitted to drive forklift trucks. Figure 14-19 nicely illustrates what can happen if the "don't" and "never" safety rules are ignored.

Handling Operations

Now that you have some background information on various containers and handling equipments, let's put it to use. The next three figures in the text illustrate certain basic handling operations. Refer to them frequently as we describe the major events. Take special note of the equipments being used. Also, use a bit of imagination and remember the versatility of these items.

NOTE: Certain key steps or events have purposely been omitted from the general descriptions that follow.

TARTAR HANDLING—CONTAINER TO DOLLY.—Figure 14-20 shows a typical Tartar/Standard MR handling sequence. In this case, the missile is transferred directly from its container into a dolly.

View A shows a forklift truck moving a Mk 372 container to a designated handling area. Note that the forklift tines are lowered and the container rides near ground level. This is the safe way, considering center of gravity and counterbalance factors. The forklift will deposit the container on a flat, even surface (either on a pier or AE-type ship's deck).

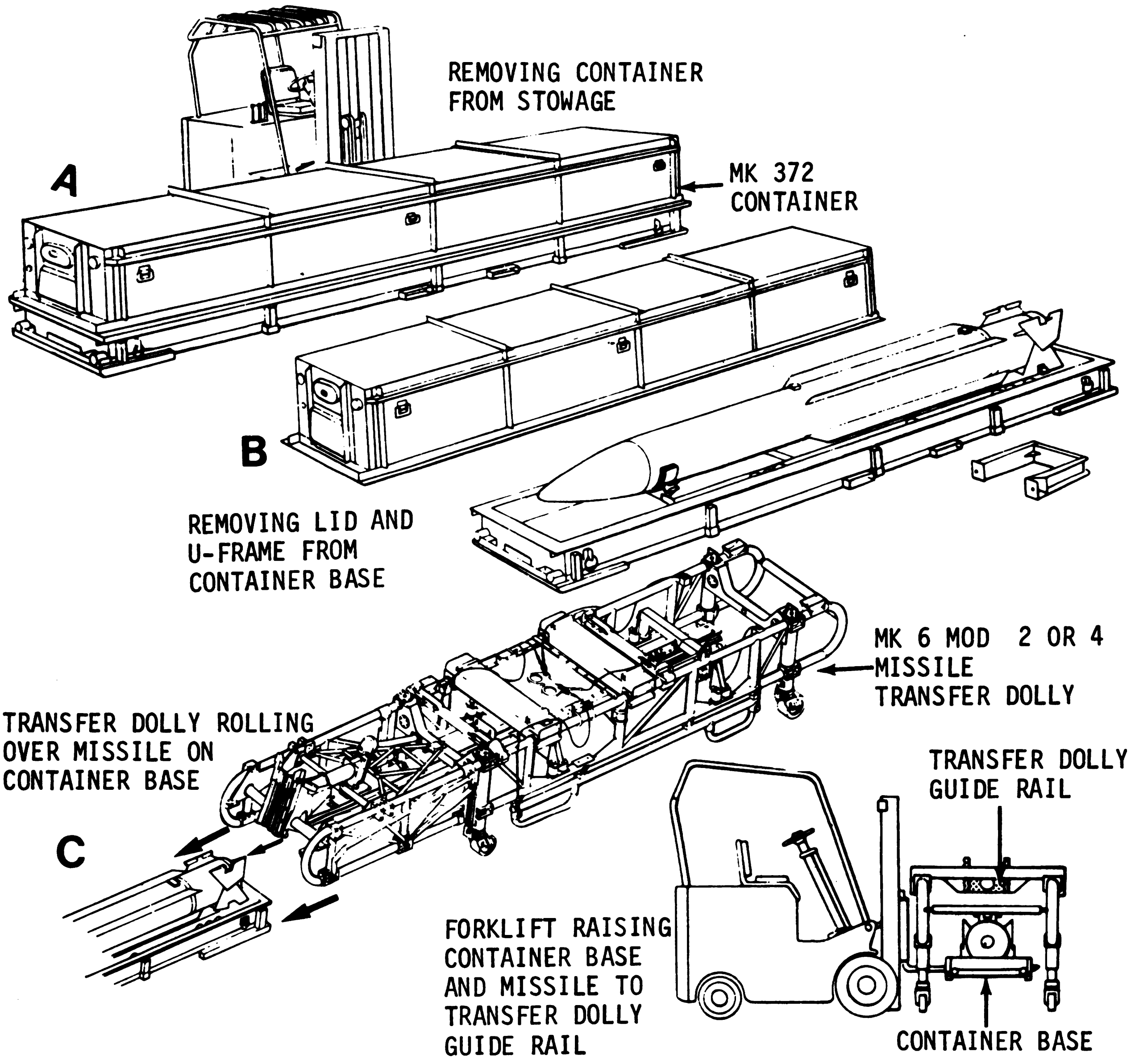
View B shows the container being prepared. The lid is unlatched, lifted from the base, and hand-carried from the immediate loading area. That makes room for upcoming forklift and dolly movements. The center missile support (U-frame) is removed. The lower missile shoes are unlocked from the container's inner support assembly.

In view C, a Mk 6 Mod 2 or 4 dolly has been brought into position behind the container. When the dolly is aligned to the container, its wheels are locked (straight). The dolly is pushed forward over the container until the dolly's guide rail openings are over the upper missile shoes. At this point, the missile shoes are about 9 inches below the dolly's guide rail.

In view D, the forklift truck has reengaged the container. Carefully, the container is raised until the missile shoes enter the dolly's guide rail openings. The dolly is pushed so the shoes enter the guide rail tracks/slots. Locking mechanisms are turned to secure the missile in the dolly. The forklift operator lowers the empty container to the ground (pier or deck). The forklift backs away and the loaded dolly is pushed to a staging area. The container's lid is reinstalled and the empty container is removed from the area.

The procedures described above pertain to an on-load operation. An off-load sequence is essentially the reverse—the missile is transferred from a dolly directly into a container.

TARTAR HANDLING—ROLLING THE MISSILE.—In certain situations, a Tartar or


A
REMOVING CONTAINER FROM STOWAGE
MK 372 CONTAINER
B
REMOVING LID AND U-FRAME FROM CONTAINER BASE
MK 6 MOD 2 OR 4 MISSILE TRANSFER DOLLY
TRANSFER DOLLY ROLLING OVER MISSILE ON CONTAINER BASE
C
TRANSFER DOLLY GUIDE RAIL
FORKLIFT RAISING CONTAINER BASE AND MISSILE TO TRANSFER DOLLY GUIDE RAIL
CONTAINER BASE

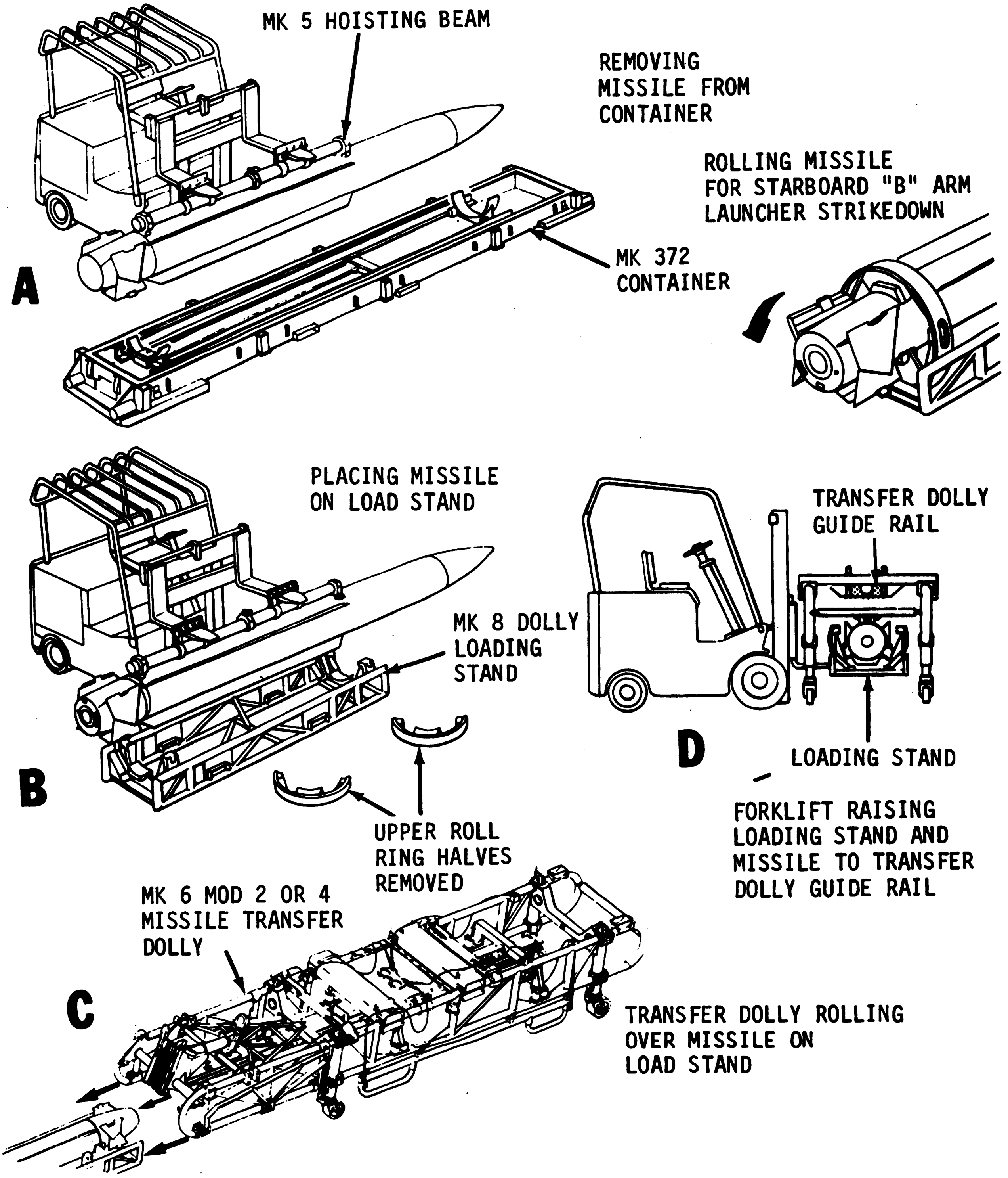
83.578

Figure 14-20.—A Tartar/Standard MR missile handling sequence; container to dolly without roll.

Standard MR missile must be rolled or turned 180°. This orients the round for B-arm loading. Figure 14-21 illustrates the key steps in this operation.

In view A, a Mk 5 hoisting beam has been attached to the missile's shoes. After the missile is unlocked from the container, a forklift carefully raises the loaded beam clear of the container's base. (This operation is often called decanning.)

View B shows the missile being lowered into a properly prepared Mk 8 dolly loading stand. When the upper ring halves of the roll ring assembly are resecured in place, the missile is rolled.


MK 5 HOISTING BEAM
REMOVING MISSILE FROM CONTAINER
ROLLING MISSILE FOR STARBOARD "B" ARM LAUNCHER STRIKEDOWN
MK 372 CONTAINER
A
PLACING MISSILE ON LOAD STAND
TRANSFER DOLLY GUIDE RAIL
MK 8 DOLLY LOADING STAND
D
LOADING STAND
B
FORKLIFT RAISING LOADING STAND AND MISSILE TO TRANSFER DOLLY GUIDE RAIL
UPPER ROLL RING HALVES REMOVED
MK 6 MOD 2 OR 4 MISSILE TRANSFER DOLLY
C
TRANSFER DOLLY ROLLING OVER MISSILE ON LOAD STAND

83.579

Figure 14-21.—A Tartar/Standard MR missile handling sequence; container to loading stand to dolly with roll.

View C shows the dolly in position to be pushed over the load stand. (The upper ring halves are removed again.) This operation is the same as that described with view C of figure 14-20.

In view D, the forklift is raising the loading stand to engage the missile to the dolly. Again, the operation is similar to view D in figure 14-20.

Now use your imagination. The Mk 5 hoisting beam in view A of figure 14-21 could be replaced with a Mk 15 beam; that is, if Mk 79 handling bands were installed on the missile. Also, in view A, the container could be substituted with Mk 100 stowage adapters or a Mk 20 stowage cradle. (Do you get the idea of the "imagining" exercise?) In view B of figure 14-21, the load stand could be a Mk 20 cradle instead. The operations in views C and D of figure 14-21 would be the same using a cradle. In certain sequences, even the forklift truck can be replaced with an overhead crane/hoist.

Again, handling equipments are very versatile. The conditions of the handling operation will dictate which equipments (or options) can be used.

TERRIER HANDLING.—Terrier and Standard ER missile handling sequences are illustrated in figure 14-22. Note the equipments used in this example. A booster would be handled in the same manner.

In view A, the missile is decanned with a Mk 15 hoisting beam attached to the handling bands. In view B, a properly prepared Mk 8 loading stand (no roll ring assemblies installed) receives the missile. A Mk 20 cradle could easily be substituted at this point.

In view C, a Mk 6 Mod 1 or 3 transfer dolly is ready to be rolled over the round. When the dolly is in position, the forklift truck raises the stand or cradle (view D). The handling bands are attached to the dolly's frame and the forklift lowers. An off-load sequence is just the reverse.

Figure 14-22 illustrated the major events required to load a Terrier/Standard ER round into a Terrier transfer dolly. The mandatory piece of equipment in this operation was the dolly loading stand. To understand this point, refer to figure 14-20. It shows a Tartar/Standard MR missile being loaded to its transfer dolly directly from a container. Terrier/Standard ER rounds cannot be handled that way. The Terrier transfer dolly can't be rolled over the larger (wider and taller) Mk 199 and Mk 200 containers. Therefore, a dolly loading stand (or cradle) is necessary when Terrier on-loads or off-loads are performed with a transfer dolly.

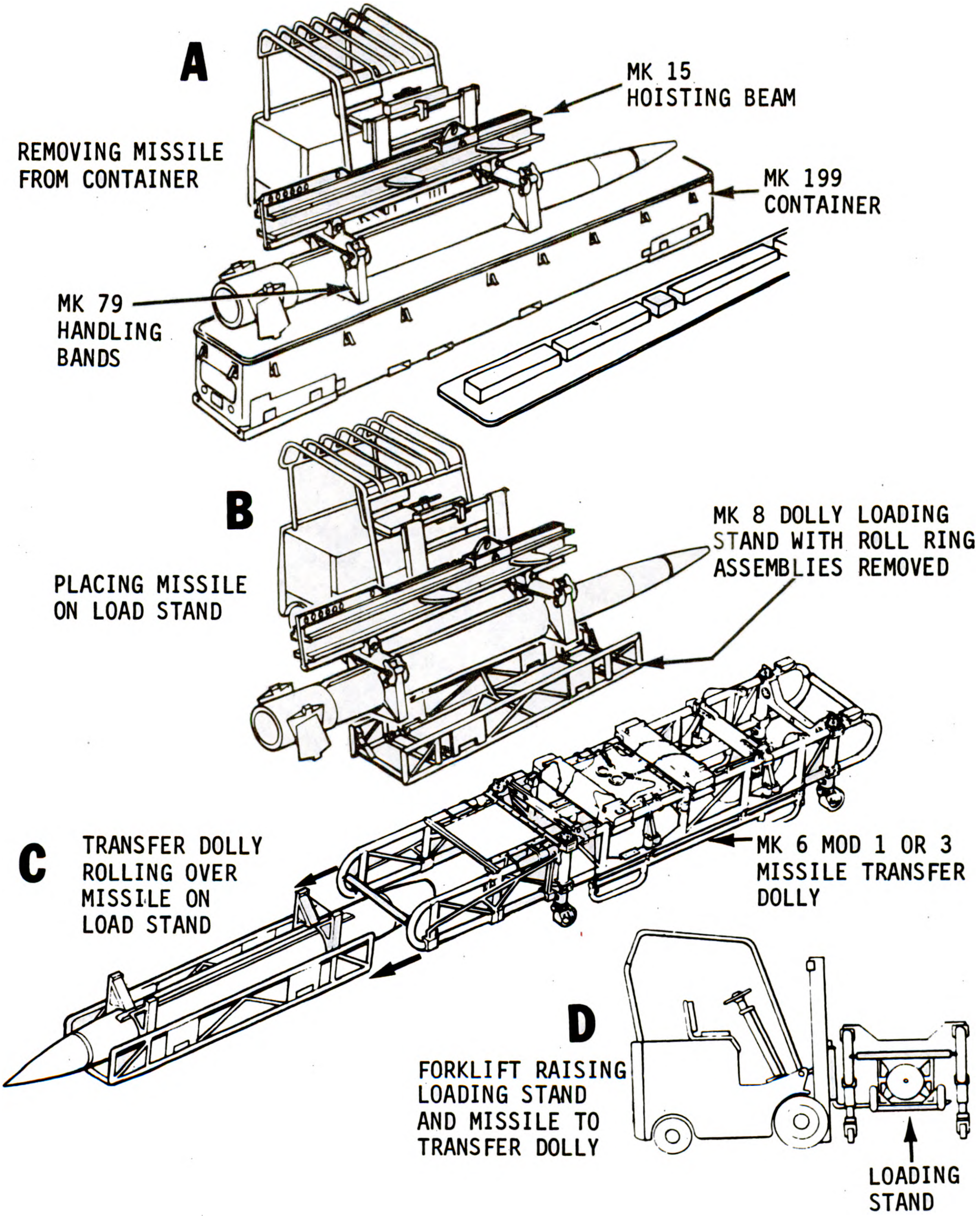
Generally, a Terrier transfer dolly is used only during underway replenishments. (Replenishment methods are the next subject in the text.) The handling operations seen in figure 14-22 would be performed aboard an AE-type ship.

Dockside (or pierside) Terrier replenishments are handled in a slightly different manner. A transfer dolly is not used. Refer to view A of figure 14-22 and mentally remove the forklift truck from the picture. With the round still in its container, a sling is attached to the Mk 15 hoisting beam. A crane then lifts the missile straight up and out of the container. The crane swings the missile to the ship and lowers it directly onto the arms of the GMLS's raised strikedown elevator. The handling bands are secured to the elevator. Then the hoisting beam is disconnected from the handling bands. The crane swings the empty beam back to the pier to pick up the next load. This procedure has several advantages. It eliminates loading a dolly, saves time, and involves less handling of the weapon.

There is yet one other method available to onload/off-load a Mk 10 GMLS without using a transfer dolly. Do you remember how it is done? (Refer to figure 3-14.) Handlift trucks are used to move the container under the guide arm. After the guide arm is elevated, the Mk 21 guided missile hoist is fastened to the handling bands. Depressing the guide arm decans the round.

REPLENISHMENT METHODS

Earlier in the text, we briefly touched upon the subject of replenishment. (Refer to chapter 3's strikedown section.) We learned there were various methods used to transfer missiles between


A
REMOVING MISSILE FROM CONTAINER
MK 15 HOISTING BEAM
MK 199 CONTAINER
MK 79 HANDLING BANDS
B
PLACING MISSILE ON LOAD STAND
MK 8 DOLLY LOADING STAND WITH ROLL RING ASSEMBLIES REMOVED
C
TRANSFER DOLLY ROLLING OVER MISSILE ON LOAD STAND
MK 6 MOD 1 OR 3 MISSILE TRANSFER DOLLY
D
FORKLIFT RAISING LOADING STAND AND MISSILE TO TRANSFER DOLLY
LOADING STAND

83.580

Figure 14-22.—A Terrier/Standard ER missile handling sequence; container to loading stand to dolly.

two activities. These methods included UNREP-CONREP, VERTREPs, and pierside and lighter operations using a crane. The following areas of the text describe these methods in more detail. Essentially, we'll see how a transfer dolly (or container) is delivered to a combatant ship.

Experience and on-the-job training are the best teachers in replenishment operations. However, you should have a general understanding of how the different evolutions are performed. You must also realize that any replenishment is (1) a team effort, and (2) a dangerous operation. All personnel involved in a replenishment must work quickly, quietly, and efficiently. Cooperation is the key ingredient.

Usually, Gunner's Mates are not directly responsible for setting up and running a replenishment. However, we may be required to assist in preparing for a replenishment (e.g., as line handlers). The ship's Boatswain's Mates normally set up and run the transfer (CONREP) rigs between ships. They will also direct a helicopter (helo) during VERTREPs. At an NWS or other pier facility, civilian workers will operate and direct a crane. These personnel are trained to do this kind of work.

Our primary job is to move the missile between the replenishment station and the GMLS's strikedown area. A coordinated team effort by handling personnel is vital in this case. Transfer dollies or containers must be moved safely and smartly. That is important in contributing to the overall smoothness of the operation.

Any ammunition transfer is a hazardous evolution considering the quantity of high explosives involved. Protective gear such as safety helmets (hardhats), steel-toed safety shoes, and lifejackets (at sea) must be worn. Rings, watches, cigarette lighters/matches, etc., must not be brought to a replenishment area. Be careful and cautious. Obey the rules and don't rush in your work.

UNREP-CONREP

The most common underway-connected replenishment (UNREP-CONREP) method for missile transfer today is called STREAM. STREAM stands for standard tensioned replenishment alongside method. It is used to transfer a variety of missile, ammunition, and other cargo loads.

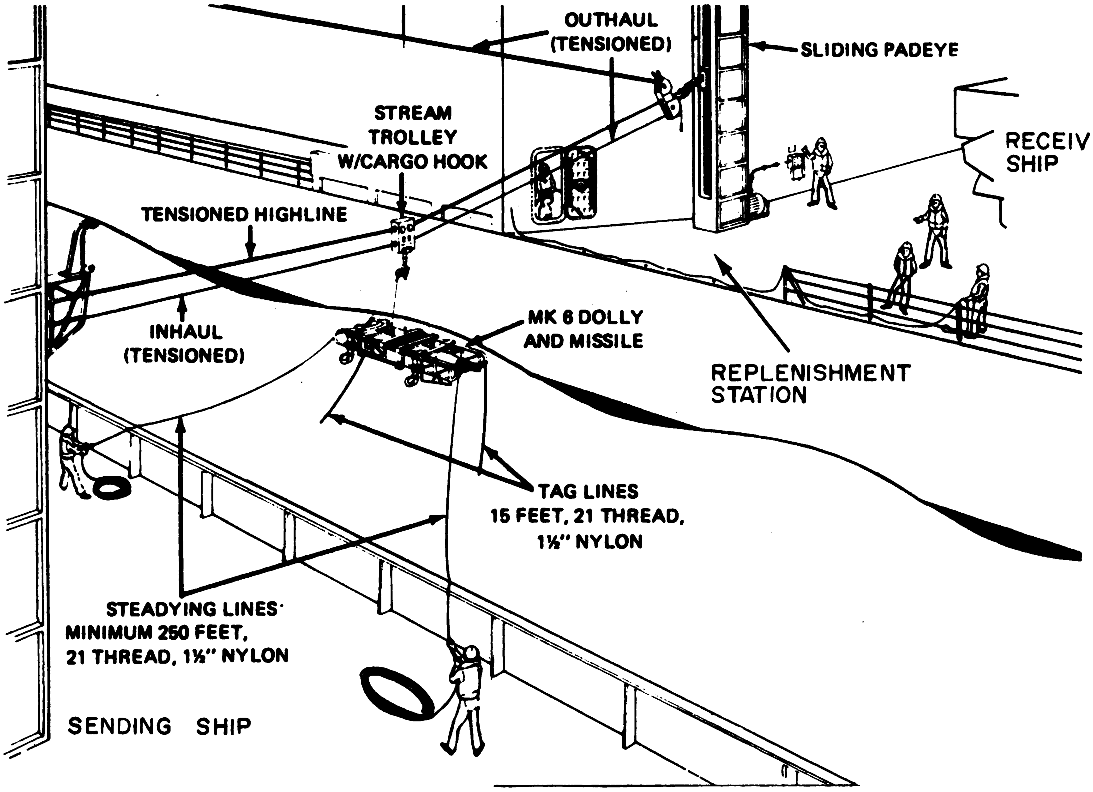
Figure 14-23 illustrates the basic arrangement for a STREAM rig. After the various lines are connected, the sending ship controls all operations. In the figure, the receiving ship is using a sliding pad eye. As the load reaches the receiving ship, the pad eye is lowered. This places the transfer dolly on deck at the replenishment station. The dolly's sling is disconnected from the cargo hook. The handling crew moves the dolly to the GMLS's strikedown area. Strikedown operations are performed and the empty dolly is returned to the replenishment station.

Additional information about CONREP procedures can be found in *Naval Warfare Publication (NWP) 14, Replenishment at Sea.* Another good (and available) source is *Boatswain's Mate 3 & 2,* NAVEDTRA 10121-G.

VERTREP

A vertical replenishment (VERTREP) is a very efficient and versatile replenishing method. A helicopter (helo) is used to transfer just about anything anywhere. Ammunition, cargo, and personnel loads can be transported between ships, ship-to-shore, or shore-to-ship. The only limiting factors to a helo operation are the helo's range, capacity, and the weather. If the receiving ship is equipped with the proper (and required) lighting, nighttime operations are possible. However, most VERTREP ammunition transfers are conducted during daylight hours (for safety considerations).

During a missile transfer, the helo supports the load (a transfer dolly or container) on a cable/sling arrangement. As the helo approaches the receiving ship, the pilot maneuvers over the ship's "drop" zone. A landing signalman (usually one of the ship's BMs) guides the helo in with a series of hand signals. When the load is over the drop zone, the helo lowers and puts the dolly/container on deck. A hookup man (another



83.206

Figure 14-23.—Missile transfer by STREAM.

ship's BM) runs to the load and disconnects the helo's hook. The helo raises and clears the area.

When the helo is at a safe distance from the ship, the missile handling team assembles. The team moves the dolly or container to the GMLS's strikedown area. On-load (or off-load) operations are performed and the dolly/container is returned to the drop zone. The helo comes back and picks up the load. One missile VERTREP has been completed.

VERTREP is probably the most popular replenishing method today. It has many advantages, such as speed and simplicity. However, from a Gunner's Mate's point of view, two words of caution. First, any helo operation is considered a dangerous operation. Only the landing signalman and hookup man are permitted in the drop zone area while the helo is overhead. All other personnel must remain well clear of the area at this time. Foreign object damage (FOD) is another danger. Rotor blade suction will draw ANY loose objects into the helo's engine—with disastrous results. Do not wear hats (ball caps) and ensure all gear near the helo area is firmly secured.

The second word of caution applies to the load. Be sure to inspect the missile very carefully as soon as the helo clears the ship. Why do you think the helo area is called a "drop" zone? The missile can sustain some rather severe damage (shocks, bounces, jolts) as it "hits" the deck. If the damage is obvious (e.g., a cracked radome), reject the round before it is moved. Also, check the transfer dolly for damage caused by hard hits on deck. Look at the dolly wheels carefully.

DOCKSIDE REPLENISHMENT

A typical dockside (or pierside) replenishment operation is illustrated in figure 14-24. The major handling equipments and events have already been described. (See figures 14-20 and 14-21, for example). Any changes or variations to the basic steps in figure 14-24 are minor. For instance, missiles may arrive on the pier in a boxcar instead of on a flatcar. Sometimes a flatbed truck is used.

Quite often during dockside replenishments, the receiving ship is required to supply personnel to assist the pier crew. As a Gunner's Mate, you may get this assignment. You'll actually get the chance to work with the different types of handling equipments we've discussed.

LIGHTER REPLENISHMENT

A lighter is a specially constructed barge designed to carry ammunition. A typical lighter replenishment is seen in figure 14-25. The receiving ship in the figure is a combatant. However, lighter replenishment is also performed with AE-type ships.

The handling operations that take place on a lighter are the same as on a pier or AE-type ship. This includes canning/decanning, dolly loading/unloading, rolling a missile, and so forth.

Lighter replenishment is used for various reasons. Its main advantages are in time and money savings. It is cheaper and quicker to load a lighter at an NWS and deliver the missiles/ammunition to a ship. The ship does not have to get under way and that is a huge savings in fuel costs. Another point is that newer AE-type ships are deep draft vessels. They cannot always navigate the rivers and channels leading to an NWS dock. Therefore, the lighter replenishment method is gaining in popularity. Many times the lighter and receiving ship will meet halfway and conduct the ammunition transfer while at an anchorage.

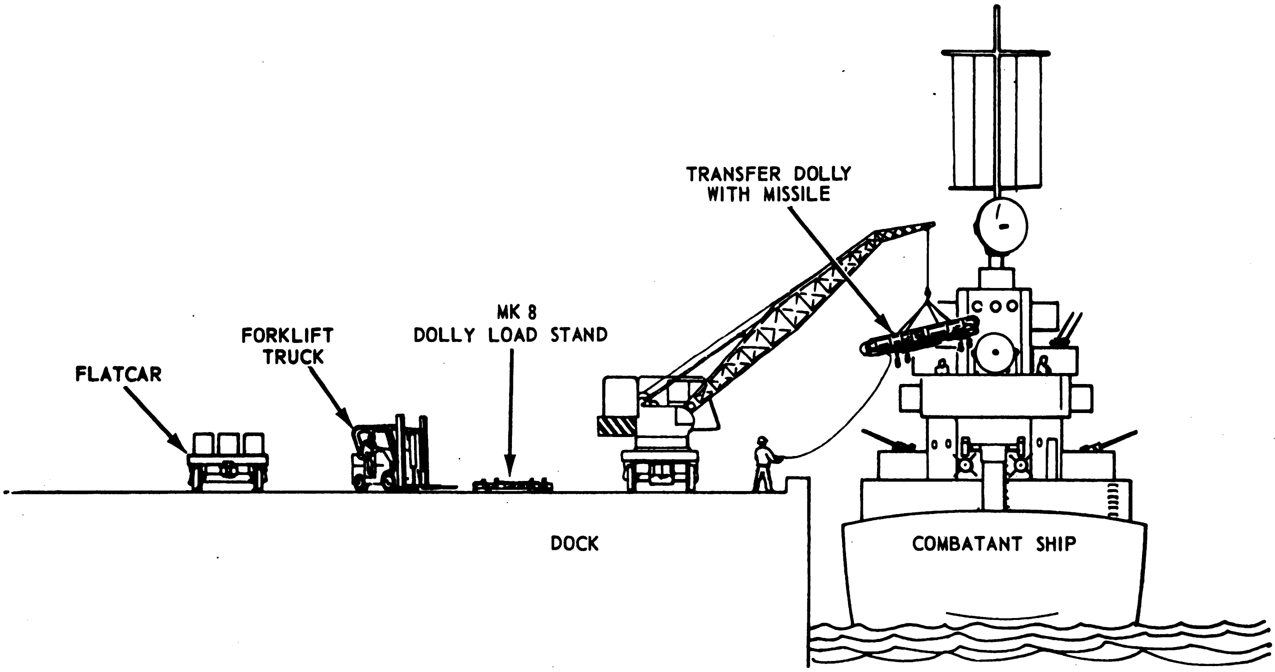


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Figure 14-24.—Dockside replenishment.

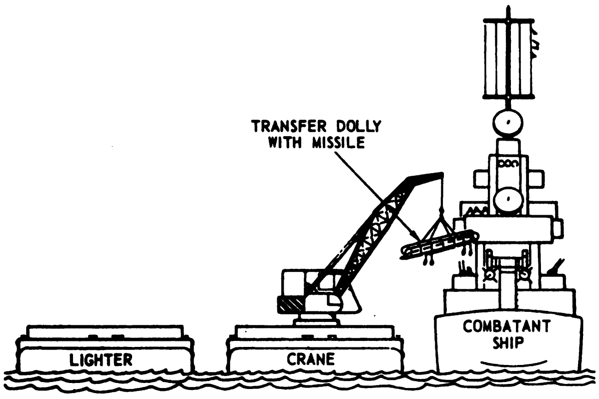


Figure 14-25.—Lighter replenishment.

This concludes our discussion of missile-handling operations. For the most part, these events occur ashore at an NWS. However, with the exception of assembling and testing, AE-type ships perform the same jobs. Our next subject area deals with the missiles after they are safely stowed aboard a combatant ship.

MISSILES ABOARD SHIP

The extent of our work with missiles aboard ship has taken some dramatic turns during the last two decades. When missiles were first introduced to the fleet, they were subjected to an extensive shipboard maintenance and testing program. Each month (usually), an integrity- or reliability-type test was conducted on every round in the magazine. These tests were commonly known as GO/NO GO tests.

GO/NO GO testing was a complicated evolution. The tests simulated certain in-flight conditions and measured specific missile responses. If the round failed the test, it was disassembled and individual sections were retested to isolate the fault. The bad unit or module was replaced with an onboard spare. Generally, the entire process was very time-consuming.

Today, guided missiles are delivered to the fleet in an all-up-round (AUR) status. All tests and certification checks are performed before the missile leaves the NWS. Aboard ship, we are no longer authorized nor equipped to disassemble, test, or repair any critical missile component.

How did the SMS community evolve from a monthly testing program to AUR status? Primarily, technical improvements and state-of-the-art circuitry increased missile reliability. If a missile is properly handled and maintained, its normal life-span is many years.

Aboard ship, our current activities with missiles can be summarized as follows:

1. Handling
2. Stowage
3. Inspections
4. Cleaning and preservation
5. General tasks

HANDLING

You will be responsible for the safe and proper handling of missiles at all times. Obviously, this point strongly applies to replenishing and strikedown operations. During these periods, the missile has minimum protection with maximum exposure.

However, do not forget launcher loading, unloading, and intersystem transfer operations. These evolutions are a form of missile handling also. Even though the missile is within the confines of the GMLS, it is still susceptible to damage. Sometimes, due to equipment failure or breakage, missile damage is unavoidable. Fortunately, such cases are extremely rare. Most missile damage is a result of personnel error.

A common cause of damage can be traced to the experienced control panel operator. Loading and unloading a launcher everyday, especially with a TSAM or GMTR, becomes second nature to some people. They soon learn the "shortcuts" of a GMLS and can "run the panels blindfolded." In short, bad operating habits are developed. Those bad habits are hard to break when a live missile must be loaded. Quite often, a shortcut that can (but shouldn't) be taken with a training missile just won't work with a live missile. You can guess the outcome.

Safe and proper handling/operating techniques MUST be practiced constantly. There is no room for error or carelessness, especially in routine shipboard tasks. Eliminate distractions and concentrate on what you're doing.

STOWAGE

You will be responsible for the care of the missiles while they are in stowage. That is an important task since a missile spends about 99 percent of its existence in stowage. A large part of this care is related to maintaining magazine environmental control and fire suppression systems in good working order.

Magazine temperature and humidity levels must be checked. If they begin to exceed established tolerances, positive action must be taken immediately. Be sure to inform your work center supervisor of the situation.

Good housekeeping has to be practiced in any ordnance stowage area. Maximum effort must be made to keep the magazine area clean. Do not let dirt, oil, or greases accumulate to create potential fire hazards. Oily rags are particularly dangerous.

Missile airframes are not watertight structures. That point was emphasized when we discussed training missiles near the end of chapter 9. Live missiles are subject to the same corrosive damage as are training missiles. Although the problem is not as acute with live missiles (because they are handled less), it is just as serious. Don't let the live missile get wet.

Since (live) missiles are in stowage most of their time aboard ship, how can they get wet? Unfortunately, magazine sprinkler wetdown is all too often the cause. And, as you know, most wetdowns are generally traced to personnel error. We won't repeat the applicable sprinkler warnings, although they cannot be stressed enough. An important point to remember is that ANY wetdown experience MUST be immediately reported through the chain of command.

Special measures must be taken if the missiles have been exposed to salt water, as from a wetdown. Each missile must be examined carefully for any evidence of saltwater contamination. Give particular attention to all joints, launching shoes, and firing contacts. DTRMs and boosters that had water enter their bore must not be used. These rounds (with wet rocket motors) must be returned to an NWS.

Corrective action after a wetdown involves washing the missile with fresh water. The missile is then dried and corrosion preventive compounds are applied. Every missile subjected to wetdown must be reexamined within 30 days. Details as to the extent and location of corrosion must be noted in the missile's service record. If the problems are severe enough and continue to worsen, the missile(s) may be totally ruined. Therefore, after any wetdown, the missile(s) must be turned in to the nearest NWS or missile handling facility.

INSPECTIONS

You will be required to inspect the missiles at different intervals. Generally, these inspections are visual and are limited to the external surfaces of the round. Inspection procedures and points to check are outlined on maintenance requirement cards (MRCs) or in the applicable OPs. You check different things on different missiles, so be sure to refer to the applicable references.

Normally, missile inspections can be divided into three major periods—receipt, routine, and off-load. There are special inspection situations such as after a casualty wetdown or dud/misfire occurrence. Appropriate MRCs or missile handling OPs (for Terrier systems) exist to provide instructions for these conditions.

The receipt or on-load inspection is very important. Before the missile is moved to the magazine, go over it with a fine-tooth-comb. Using an MRC/OP as a guide, check for cracks, dents, chips, and other external surface damage. Ideally, a radome's surface should be perfectly smooth. But, sometimes, bubbles will appear on its surface. The MRC/OP will give size-tolerances of these bubbles; if they are beyond a certain dimension, the round must not be used.

Ensure all control surfaces are installed and folded correctly. Verify that all safety wiring and protective seals are intact. Antenna surfaces must not be soiled or scratched. If you discover or think you've discovered a problem during a receipt inspection, notify proper authority immediately. If the problem can be verified to be beyond acceptable standards, the ship can reject the missile.

Periodically, every missile must be removed from the magazine and given a routine inspection. The interval of routine inspections may vary, but semiannual and/or annual inspections are most common. Many of the same points checked during a receipt inspection are rechecked. Cleaning and preservation work is also performed. Routine inspections are important checks as they contribute to the long-term reliability of the missile.

An off-load inspection is conducted as the missile leaves the ship. If you have faithfully performed the other inspections, the off-load checks should go rather quickly.

The results of any inspection will be logged in a guided missile service record (GMSR). Compare a GMSR to your own health or dental record. Any time you have a physical, the results are recorded to establish your medical history or file. The same thing applies to a missile and its inspection results. (A GMSR will be described in the next chapter.)

CLEANING AND PRESERVATION

You will be responsible for the cleanliness and preservation of the missiles. These actions are normally performed as part of the routine inspection procedures.

Without fail, your missiles WILL get dirty. They'll get stained from oil and grease drippings and even shoe polish scuff marks. Missiles are not cleaned and preserved just to make them "look pretty." This work is accomplished for some very valid reasons. Cleanliness directly contributes to the round's prelaunch and in-flight performance.

For example, we mentioned antennas as an item you had to inspect. Suppose a big glob of grease falls onto a proximity antenna. Yes, that glob of grease could affect the operation of a warhead's fuze by blocking or distorting the transmitted/received signal. What if a movable tail-control surface rusted in place? Steering and stability control would be severely hampered. Items such as these must be checked, cleaned, and preserved.

Cleaning generally involves the use of good old soap and water along with elbow grease. The outer surfaces of the missile are washed to remove any accumulations of unwanted materials. Be sure to consult the maintenance instructions and use the approved detergents. Warnings will often be included stating where abrasive cleansers (like scouring powder) may or may not be used.

Preservation involves applying corrosion preventive compounds to the external surfaces of the missile. These compounds are designed to resist the effects of moisture on a metal surface. The MRC/OP instructions will specify the currently approved materials and explain where and how to apply the compounds.

GENERAL TASKS

Aside from routine maintenance procedures, you must be able to perform certain practical tasks on a variety of missiles. Some of the items listed below will pertain only to specific missiles we've studied. Other points can be applied to all missiles in general.

You may be required to—

1. mate and unmate a missile-booster combination.
2. load and unload an ASROC weapon to/from an ASROC adapter rail.
3. install and remove booster fins and missile tail-control surfaces.
4. fold and unfold missile tail-control surfaces.
5. replace external missile components such as dorsal fins.
6. demonstrate the ability to safely handle and prepare a nuclear weapon for firing.
7. demonstrate the ability to identify a dud or misfire condition and perform applicable handling procedures.

The skills mentioned here are by no means an all-inclusive listing. You will receive the necessary practical training to perform these kinds of tasks. Accomplish them deliberately, properly, and above all, safely.

MAGAZINES

As a Gunner's Mate, you are required to have a working knowledge of all shipboard magazines. A magazine is any compartment, space, or locker used, or intended to be used, for ammunition stowage.

Shipboard magazines are arranged so ammunition transfers can be performed easily, conveniently, and safely. They are designed to provide the most favorable stowage conditions for their contents. Magazines also are located where they can receive the best protection from external and internal influences. For example, you won't find a magazine located next to a ship's boiler room.

From magazines, we can expand to the term "magazine area." A magazine area includes all compartments, spaces, or passages next to or surrounding a magazine. These places are used, or intended to be used, for the handling and passing of ammunition. The areas around loaded lighters, railroad cars, and trucks are treated as magazine areas, too. The safety and security measures applicable to shipboard magazines and magazine areas also apply to these "portable" units.

TYPES OF MAGAZINES

There are many types of magazines aboard any ship. Consider the examples listed below.

1. Fixed-ammunition magazines
2. Powder magazines
3. Projectile magazines or rooms
4. Missile magazines
5. Bomb magazines
6. Warhead magazines
7. Fuze magazines
8. Small arm magazines or lockers
9. Detonator lockers
10. Pyrotechnic magazines or lockers

Each magazine is specifically designed for the ammunition it is to contain. As a general rule, different types of ammunition will be stowed in separate magazines or lockers. The highest possible degree of safety is obtained by not mixing different explosives.

However, there are exceptions to this rule. Some stowage areas can be designated single-purpose or multipurpose magazines. While single-type stowage is desirable, it is not always possible. Often a ship's mission requires it to carry a variety of ammunition. Mixed-stowage in multipurpose and certain single-purpose magazines is acceptable. But, there are limitations and restrictions to mixed-stowage. Current safety instructions must be followed and proper authorization must be obtained for mixed-stowage.

Pyrotechnics which have been removed from their containers cannot be mixed. Fuzes and detonators that are not integral parts of or assembled with their ammunition cannot be mixed. When mixed stowage is necessary (with the approved ammunitions), special precautions must be taken. Ensure the different types of ammunitions are separated/segregated within the magazine. Each piece of ammunition must be clearly marked for ready identification.

There are five major types or classes of magazines. We will discuss the four types you will most likely encounter—primary magazines, missile magazines, ready-service magazines, and lockers. The fifth type is called a chemical magazine. Only lethal and incapacitating chemical ammunitions will be stowed in these extremely special magazines. Normally, chemical ammunition is not carried aboard ship.

Primary Magazines

Primary magazines are stowage spaces that are usually located below the main deck. Preferably, they will be below the ship's waterline. Primary magazines must be well-insulated, ventilated, and have some means of temperature control. They must also have a sprinkler system capable of being activated from remote and local stations. Primary magazines must be closed and locked when unattended.

Primary magazines are designed to carry a ship's complete allowance of ammunition for peacetime operations. On SMS combatant ships, the gun magazine is normally thought of as the ship's primary magazine. If the ship has two gun mounts, we then have two primary magazines. Aircraft carriers and AE-type ships also have spaces designated and equipped as primary magazines. Ammunition stowed within these magazines is not necessarily gun ammunition. However, the same principles apply.

Missile Magazines

Due to the nature of guided missiles, a fine-line distinction does exist between a missile magazine and a primary magazine. Most of the differences are minor and can be related to two factors.

First, GMLS missile magazines contain many electrical and hydraulically powered equipments. Quite often, there is little or no separation (barrier) between these equipments and the missiles. In either case, the potential for fire is greater. Fire detection and suppression assumes greater importance in missile magazines.

The second factor that makes missile magazines different is their closeness to their launchers. This closeness is necessary to reduce loading times and support high rates of fire. Thus, missile magazines are generally located above the ship's waterline. For this reason, missile magazines are less protected than primary magazines and are more susceptible to damage/fire.

Missile magazines contain special features to combat the effects of accidentally ignited rocket motors. Restraining latches (e.g., cell latches) prevent any movement of the round in the magazine. Blowout patches, relief ports, and plenum exhaust vents pass rocket motor gases to the atmosphere. This prevents internal magazine pressures from building to dangerous levels.

Missile magazines are normally equipped with special combustion detection devices. Automatic sprinkler systems, with remote and local activation capabilities, must be installed. Missile magazines also have a water injection or booster suppression system. A carbon dioxide system may be installed in some GMLS magazines, especially the unmanned spaces. These compartments are insulated and have temperature control systems. They must be closed and locked when unattended.

Guided missiles will be the only type of ammunition stowed in a missile magazine. There is one exception to this statement. Destruct or shaped charges used to destroy special weapons during abandon ship procedures are stowed in the appropriate GMLS magazines. The demolition materials must be stowed in special containers or boxes readily accessible to the missiles.

Ready-Service Magazines

Ready-service magazines are ammunition stowage spaces near the gun mount or missile launcher they serve. They provide permanent stowage for part of the ship's ammunition allowance. Generally, ready-service magazines have many of the same characteristics as primary magazines. They are insulated, ventilated, and have manually activated sprinkler systems. Ready-service magazines must be locked when not attended.

The combined capacities of a ship's primary and ready-service magazines normally stow its complete wartime allowance of ammunition. Missile magazines, although they are in a class by themselves, are sometimes considered as ready-service magazines.

Do not confuse ready-service magazines with ready-service stowage areas. Ready-service stowages are facilities in the immediate vicinity of the weapon (i.e., gun mount being served). They can include weather deck lockers, bulwark (gun shield) racks, and 5-inch upper handling rooms. Ready-service stowage is used only when the ammunition is actually required to service the weapon. Even then, the amount of ammunition stowed in the facility is kept to a minimum.

Ready-service stowages must be kept locked when not attended. However, security is still minimal. These facilities also offer the stowed ammunition the least protection from outside elements. If this ammunition is returned to a magazine, it is kept separate from other rounds. It must also be fired first during the next shoot.

Lockers

A locker can be a small compartment or space. More often though, a locker is a metal box-like structure. In either case, a locker provides stowage for special types of ammunition. For example, detonators and pyrotechnic devices are stowed in lockers.

Lockers are frequently located on a ship's weather deck. They will be close to the weapon or area they are intended to serve. A label is installed on the outside of each locker. It will clearly identify the type of explosives contained within the locker. Lockers must be kept closed and locked when unattended.

The contents of a locker must be arranged in a neat and orderly manner. When the locker's lid or door is closed, it cannot contact (or jam) any part of the ammunition. Securing and safety latches, hinges, and other hardware must be well-maintained and in good working condition. Sometimes lockers are equipped with a sprinkler or flooding system. If such a system is installed, clear and legible operating instructions must be prominently displayed.

MAGAZINE MAINTENANCE AND EQUIPMENTS

Every magazine exists for one purpose—to provide safe stowage for live ammunition. Any magazine, and especially a missile magazine, must be kept clean. Particular efforts must be made to eliminate every possible fire hazard.

Only authorized personnel are permitted to enter a magazine. This rule has its roots in both security and safety reasons. An access list will identify those individuals who have been cleared to enter a magazine. The list will be kept current and is signed by the commanding officer. Quite often, personnel in other ratings may need to enter a magazine. For example, you may need some electrical work done. A ship's Electrician's Mate (EM) will be included on the access list for just such reasons. However, you will still have to escort and stay with the EM until the job is finished. Also, magazines are no place to sit around and "shoot the breeze." You enter the area, do the required work, and leave with minimum delay.

Magazine Alarms and Sensors

Missile magazines are equipped with various alarm and sensing devices. When activated, they provide audible and visual warnings that something is wrong. The alarm may mean an actual problem exists or a potential problem is developing. Immediately investigate any activated alarm.

Four common alarm circuits/systems are the—

1. FH alarm circuit.
2. F alarm circuit.
3. combustion gas and smoke detector system.
4. FZ alarm circuit.

FH ALARM CIRCUIT.—The FH alarm circuit is used with a magazine's sprinkler system. There are two things we want to be "alarmed" or warned about regarding a sprinkler system. First, we need to be made aware of leakage. Leakage indicates a problem is developing. A water valve may be leaking by or air/nitrogen pressure is dropping.

Second, we need to be made aware of system actuation. That means water is flowing and the missiles are getting sprayed. Actual sprinkling can result from a real fire or a high heat buildup in the magazine. It also could result from a gross sprinkler system malfunction. In any case, the problem has passed the development stage. Appropriate action must be taken immediately.

FH alarm switches were discussed in chapter 3. A dry-type sprinkler system uses two separate switches—leakage alarm and operation (flow) alarm. Refer to figure 3-37 and locate these switches. Both switches are installed on the dry side of the main sprinkler control valve. (Figure

3-43 shows the leakage alarm switch in greater detail.)

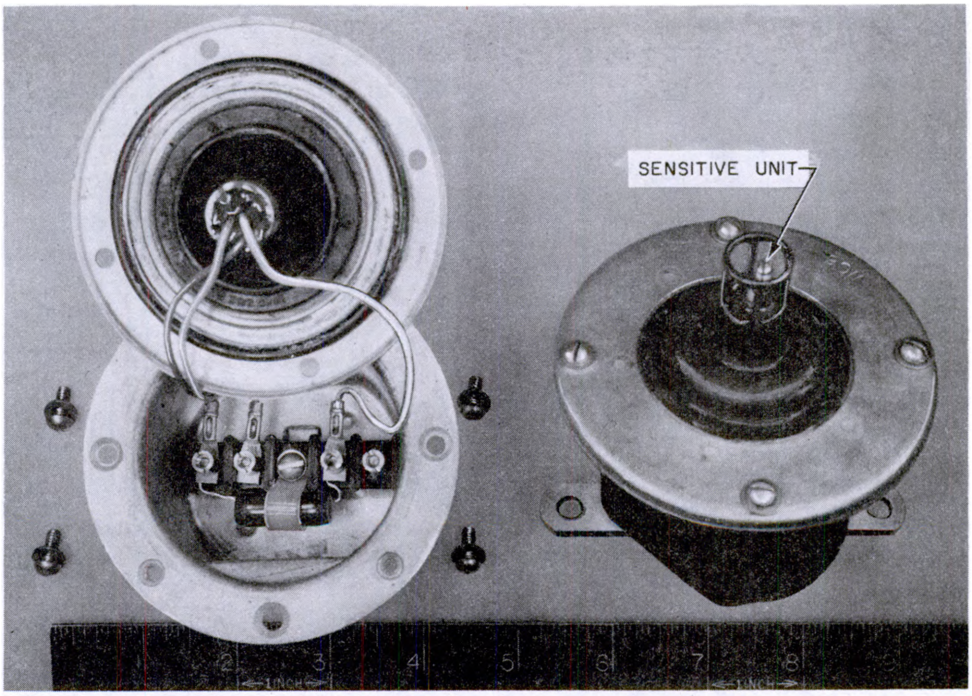
The wet-type sprinkler system used in the Mk 10 GMLS also has two water alarm switches. Refer to figure 3-44 and locate the FH alarm switch on the gravity freshwater accumulator tank and the low pressure switch in the pilot pressure line. The wet-type sprinkler system used in the Mk 13 Mod 4 GMLS has one operation alarm switch. Refer to figure 3-46 and locate this switch on the accumulator control tank. (The switch is identified as SIZ2.) If you recall, the switches in wet-type sprinkler systems do double duty. They serve as combined leakage and flow alarm indicators.

Magazine CO_2 and water injection systems also have operation or flow alarm switches. The principles and purposes are the same. Refer to figure 3-30 and locate the operation alarm switch in the CO_2 system. Refer to figure 3-33 and locate the flow switch in the water injection system.

F ALARM CIRCUIT.—The F alarm circuit is also known as the high temperature alarm circuit. It sounds an alarm when magazine space temperature reaches a dangerous level. If the F alarm sounds, investigate the problem immediately! If you react fast enough, maybe measures can be taken to reduce the temperature. This could prevent the sprinkler system from activating.

The sensing device for an F alarm circuit is a mercury thermostat (figure 14-26). The basic thermostat is designated Type IC/J-105 which activates at 105 °F. (Types IC/J-125—125 °F and IC/J-150—150 °F are available also.) A missile magazine normally has a minimum of two IC/J-105 thermostats. These units are maintained by the ship's Interior Communication Electricians (IC men/rating).

COMBUSTION GAS AND SMOKE DETECTION SYSTEM.—Missile magazines usually contain a combustion gas and smoke detection system. It is another early warning system similar to a smoke detector in a house. The system detects the presence of combustion gases and smoke particles in the air.



27.308

Figure 14-26.—Mercury thermostat type IC/J105; F alarm circuit.

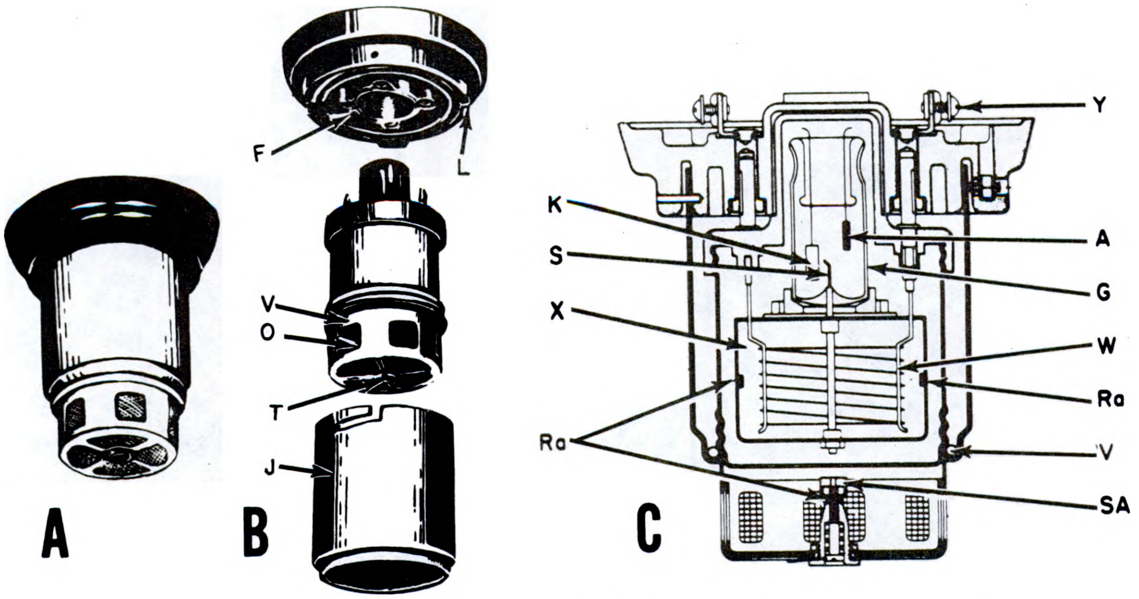
The sensing device is a combustion gas and smoke detector head (figure 14-27). (There are several detectors on the market; Pyro-a-larm is one common brand name.) Essentially, the detector compares the air in its inner chamber with the air in its outer chamber. The detector activates when combustion gases and/or smoke are present in the outer chamber. Its cold cathode tube fires (conducts) and supplies enough current to energize an alarm relay.

The important point to remember is that the detector is triggered by combustion particles. These particles are formed in all types of fires and in smoldering or overheated materials. They are so small they are invisible to the human eye. However, the particles ARE present before there is any evidence of flame. The larger particles are visible in the form of smoke.

The ship's IC men also maintain the combustion gas and smoke detector system. The advantages of this system are listed below.

1. It provides a very early warning which permits an area to be safely evacuated. It also gives more time to fight a fire while it is still small and controllable.
2. It may be adjusted or calibrated to ensure proper operation regardless of shipboard location.
3. A standard two-wire electrical circuit is used with the system. Because of the low current requirements of the circuit, thin-walled conduits can be used.
4. Any failure in system wiring or other essential component is immediately indicated on a trouble board.

FZ ALARM CIRCUIT.—You can compare an FZ alarm circuit to a burglar alarm system. They share a similar purpose—to provide a warning of a security or intruder alert. Due to the



X – INNER OR REFERENCE CHAMBER; O – OUTER OR DETECTING CHAMBER; Ra – RADIUM SOURCES; SA – SENSITIVITY ADJUSTMENT CAP; T – SENSITIVITY ADJUSTMENT SCREW; G – GAS DISCHARGE (COLD CATHODE) TUBE; A – ANODE; K – CATHODE; S – STARTER ELECTRODE; W – INNER WIRE GRID ELECTRODE; J – LOCKING SHELL; V-O RING; F – SOCKET BASE; L – LOCKING SET SCREW; Y – TERMINAL SCREWS.

27.310

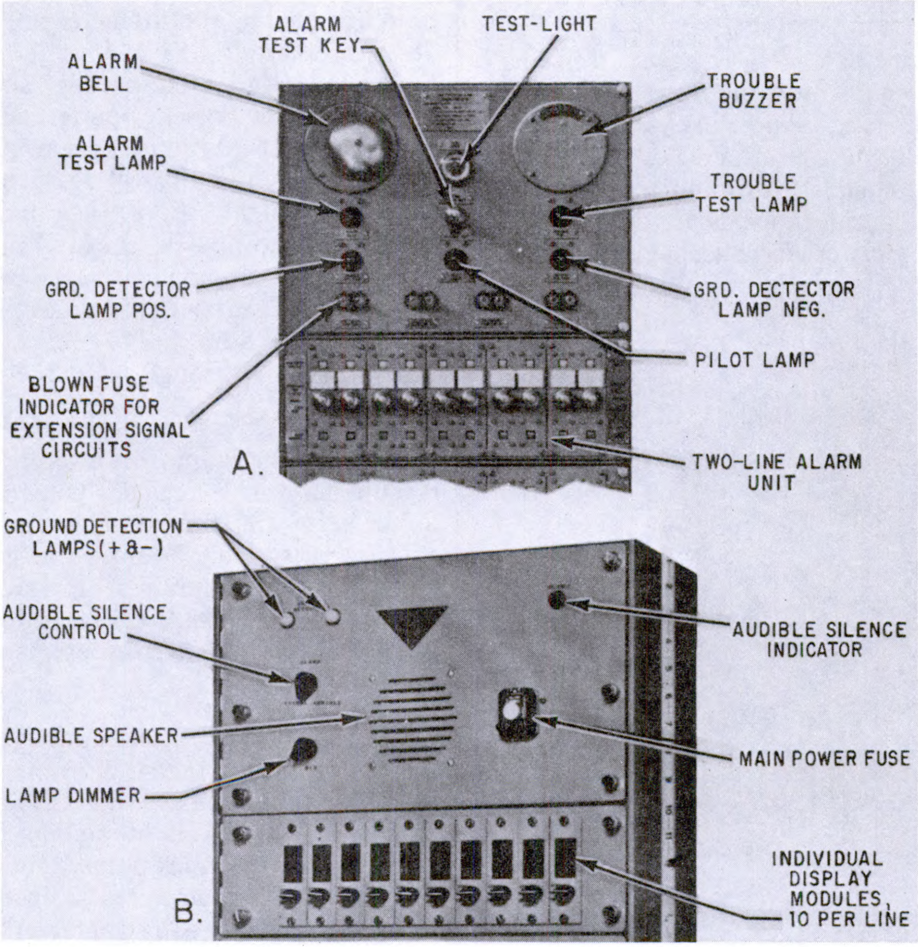
Figure 14-27.—Combustion gas and smoke detector head: A. Assembled unit; B. Major external parts; C. Internal components.

sensitive nature of the items stowed within ordnance magazines, FZ alarms are quite important. Normally, an FZ alarm circuit is associated with nuclear weapons spaces. Other magazines, such as a small arms magazine, may be equipped with some type of security alarm system also. Additional information pertaining to security alarms will be discussed in the next chapter.

ALARM SWITCHBOARD.—The circuits/systems we've just described are designed to produce audible and visual alarms. But where are these alarms and who hears and/or sees them?

Most alarm circuits throughout a ship connect to a central alarm switchboard. Figure 14-28 illustrates partial views of the older and newer types of switchboards in use today. They are installed in a space that is continuously manned while both under way and in port. Such locations are a ship's central control station, damage control (DC) central, the IC room, or combined IC and gyroroom. Each switch on the board has a nameplate to identify the space or compartment it serves.

Extension alarms for the circuits must be installed at other shipboard locations. Typical places include the pilothouse, port and starboard quarterdeck stations, and so forth. These extension alarms will simultaneously activate with the main alarm switchboard. Instruction plates identifying the system involved, the meaning of



27.307

Figure 14-28.—Two types of alarm switchboards.

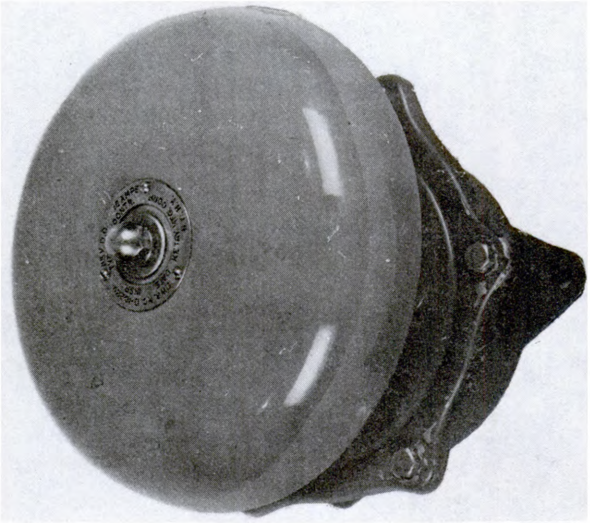
the alarm, and the emergency action required will be posted next to these alarms. Figure 14-29 shows a type of extension alarm used with an alarm warning system.

Magazine Temperatures

The main item of a daily magazine inspection is to check and record space temperatures. If you recall, temperature is the single most important factor that affects powder and propellant stability.

Temperature readings normally are taken once a day. The exact time may vary, but most ships take the readings in the morning (around 0800 for example). A special maximum and minimum thermometer is used. (Sometimes it's called a high-low thermometer.) Figure 14-30 illustrates a typical maximum and minimum thermometer.

Every magazine or locker will have at least one such direct reading thermometer. It will be located where maximum space temperature variations will normally occur. It must be installed so it is readily accessible for taking readings and resetting the index pointers. Special brackets are available to mount the thermometer where accidental damage can be averted.



27.298

Figure 14-29.—Typical extension alarm; IC/B2D4 bell.

View A of figure 14-30 shows the internal components of the device. The temperature-sensitive element is a single helix low-mass coil. The coil fits closely inside the thermometer stem. The bimetal element is carefully sized and aged for lifetime stability. The element is covered with a fluid to assure good heat transfer. The fluid also permits maximum speed of response and reduces pointer oscillations caused by outside vibrations. The case and stem are made from stainless steel for strength and anticorrosion purposes.

View B of figure 14-30 illustrates the dial face of the thermometer. It is 3 inches in diameter. A plastic window protects the index pointers. The index reset arm is on the outside of the window and is used to reset the high-low pointers. Temperature gradations on our example are marked off in 20° increments. The approximate readings on this thermometer are 100°F, high; 78°F, present; and 55°F, low. After you record these temperatures, reset the high and low pointers in line with the present pointer. As temperature rises during the day, the present pointer pushes the high pointer up the scale. As temperature falls during the night, the present pointer reverses direction. It now pushes the low pointer down the scale. As the sun comes up, the present pointer moves up the scale. Thus, we see three different temperature readings. They reflect the temperature variations throughout a 24-hour period.

The 45° spread between the high and low pointers in our example is a bit large. However, it could happen. The reading you must be cautious about is the 100°F high. The magazine A/C or ventilating system should be turned on in this instance. The optimum temperature should be around 70°F. If the A/C system is not working, artificial cooling (fans, blowers) might have to be used.

The bimetallic maximum and minimum thermometer described is becoming the standard thermometer in shipboard magazines. You may come across a different model. It only has a maximum (high) index pointer and a reset knob. This type of thermometer is acceptable. The older liquid-in-glass (tube) mercury high-low thermometer is no longer authorized for shipboard use. These mercury units must be replaced with the bimetallic-type thermometer.

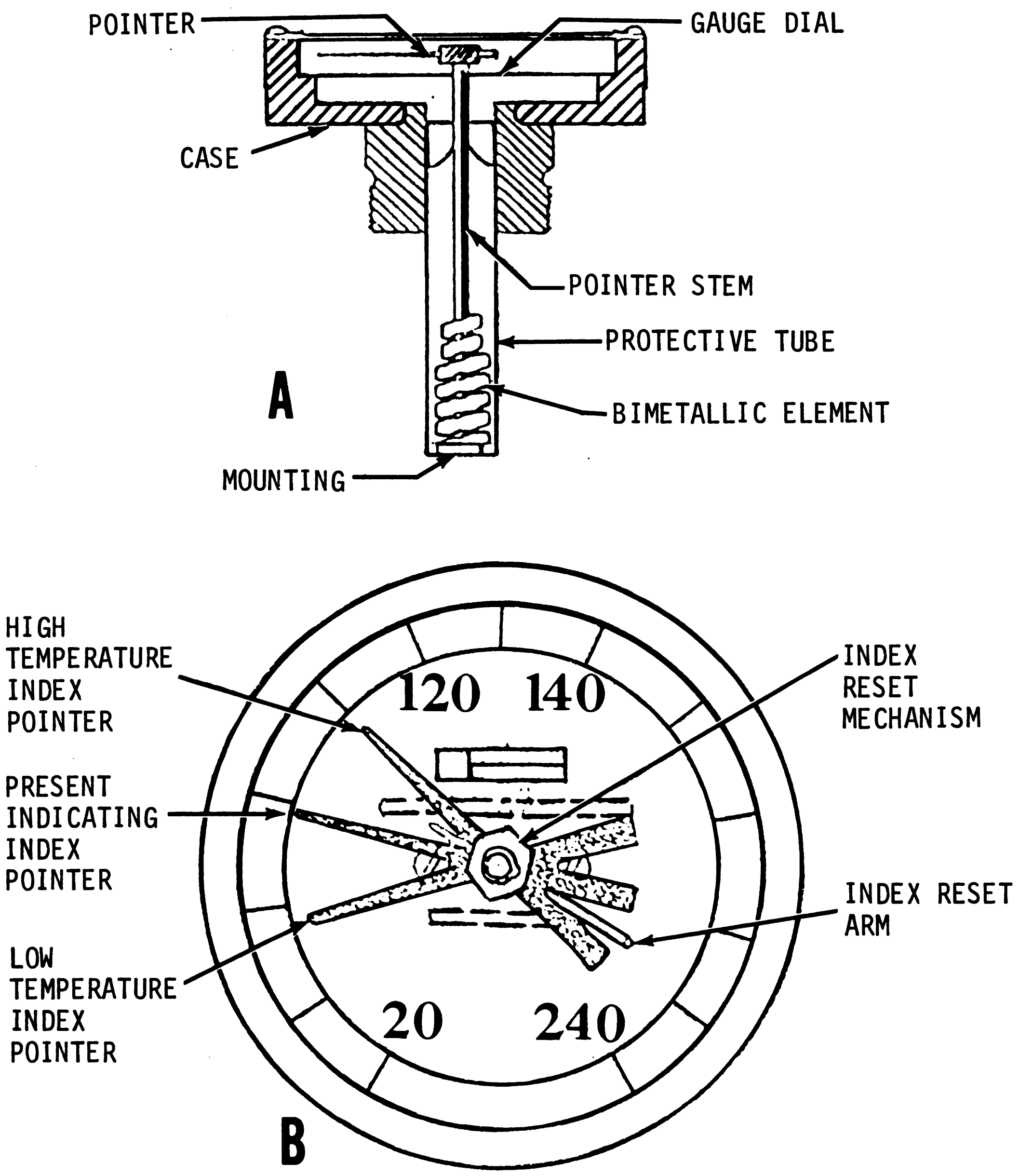


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Figure 14-30.—Bimetallic maximum and minimum thermometer: A. Internal components; B. Dial face and pointers.

Relative Humidity Indicators

Many types of ammunition are adversely affected by excessive levels of moisture. Guided missiles are no exception and must use some means of humidity control while in stowage.

In the simplest form, guided missiles are protected from excess humidity in their shipping containers. The closed container creates an airtight seal for the missile. Packets of desiccant, usually a silica gel, are placed inside the container to absorb moisture. A humidity indicator on the outside of the container changes color as the humidity increases.

The humidity level of a magazine must also be checked regularly. One type of relative humidity indicator in common use is a wet-bulb thermometer or psychrometer. Generally, the psychrometer is read once a week. The magazine ventilating system should be activated or secured accordingly to adjust/correct the humidity level in the space. Humidity readings normally are not required for magazines that contain conventional ammunition only.

Miscellaneous Features

The following items located in a magazine are often taken for granted. They are standard equipments found in any shipboard compartment. Such examples include electrical outlets, lights, sound-powered phone circuits, and so forth. However, since these items are inside an ammunition magazine, special precautions must be taken.

Electrical switches, junction boxes, and convenience outlets must be protected with watertight fittings. Be sure to keep protective caps and covers installed on these fixtures. Magazine lighting may be either fluorescent or incandescent. The light fixtures must be watertight, installed properly, and be well-maintained. Be sure to use the proper size of bulb where plastic protective globes are used. Never have a naked/unprotected light in a magazine.

Sound-powered telephone circuits are usually installed in magazine spaces. They should be tested routinely and maintained in good condition. Traffic and working areas of certain magazines will have a nonskid deck covering. There are different types of coverings available, so check current instructions for the approved materials.

Ammunition magazines must be identified properly and clearly. In addition to the standard compartment designators, another important sign or label must be remembered. This marking is commonly called the AMMUNITION FAR SIDE sign or label. It means ammunition is located on the other side of a bulkhead. Work such as drilling or welding should be kept to a minimum and, if permitted, accomplished with extreme caution.

The sign (figure 14-31) will be installed on all bulkheads, decks, and overheads surrounding a magazine. On vertical bulkheads, the signs should be 5 feet above the deck and spaced every 12 feet apart. On horizontal decks and overheads, the signs should be 12 feet apart and located to ensure maximum visibility. The sign will not be installed where it is visible from outside the ship.

The sign will be a yellow rectangle, 5 inches high by 9 inches wide. The slanted lines and letters will be painted black and arranged as shown in figure 14-31. If you must reproduce an AMMUNITION FAR SIDE sign, consult *Ammunition Afloat,* NAVSEA OP 4, fifth revision. It gives the exact details/dimensions to be followed.

Daily Magazine Inspection

Every ammunition magazine aboard every U.S. Navy ship must be inspected daily. This inspection must be made by qualified personnel. In addition to taking temperatures, the major part of the inspection is visual. Sometimes a checksheet is provided to ensure that no hazard or abnormal condition is overlooked.

Listed below are a few examples of what is observed during a typical inspection.

1. Improperly secured stowage
2. Unsatisfactory protective packing
3. Evidence of temperature and humidity fluctuations
4. Unusual fumes or odors
5. Evidence of localized overheating from adjacent compartments on decks, overheads, and bulkheads
6. Indications of leaks from sprinkler and injection system piping, valves, and nozzles
7. Inoperable or damaged automatic fire alarm devices
8. Evidence of tampering to gain access
9. Evidence of theft

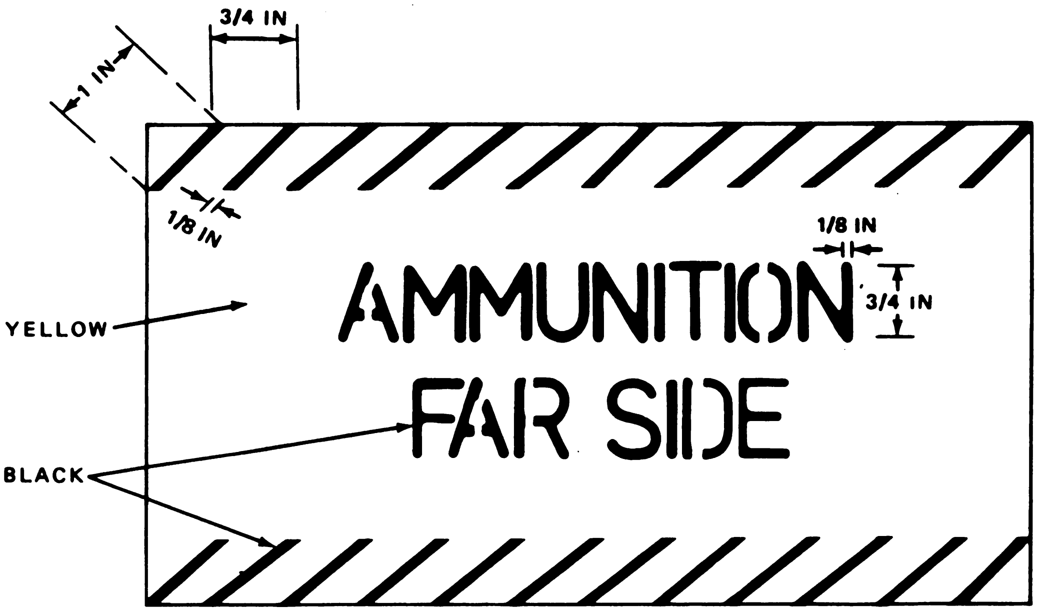

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Figure 14-31.—Sample AMMUNITION FAR SIDE sign or label.

Many hazards or abnormal conditions can be identified with the human sense—touch, smell, sight, hearing, etc. If a problem is discovered, correct it or get help to correct it, and inform the proper authority. Magazine inspections are an important part of your job as a Gunner's Mate. Do not take this responsibility lightly—the safety of your ship and its personnel are at stake.

REFERENCES

The following publications were used as reference sources to develop this chapter's material.

1. NAVEDTRA 10199-C, *Gunner's Mate M 3 & 2*

2. NAVEDTRA 10200-D, *Gunner's Mate M 1 & C*

3. NAVEDTRA 10185-C, *Gunner's Mate G 3 & 2*

4. NAVEDTRA 10186-D1, *Gunner's Mate G 1 & C*

5. NAVEDTRA 10559, *IC Electrician 3*

6. NAVSEA OP 2979, *Terrier, Tartar, and Standard Missile Containers and Handling Equipment*

7. NAVSEA OP 3206, *Handling and Stowage of Naval Ordnance Aboard Ammunition Ships*

8. NAVSEA OP 4, fifth revision, *Ammunition Afloat*

CHAPTER 15

ADMINISTRATION AND SECURITY

The topics introduced in this chapter are (1) administration and (2) security. Notice we said "introduced." Both topics cover enormous amounts of subject matter. Our object is to highlight the information you must be familiar with at this point in your career. As you advance, your duties and responsibilities in administration and security matters will increase accordingly.

In one sense, administration deals with the effective management and supervision of an organization. Your immediate concern is with the administration of a GMLS work center. As a work center member, you ARE an important partner in its administration/management. In another sense, administration is often associated with office duties or "paperwork." That means filling out forms, writing reports, and "pushing a pencil" in general. Granted, a certain amount of administrative paperwork exists. No organization or company in the world is free from paperwork.

You must realize that the administrative items available to us are, in fact, tools. These "tools" are designed to HELP us do our jobs. We can benefit from them if they are understood and used correctly. Some of the basic administrative areas introduced in this chapter are listed below:

1. Publications
2. Logs and records
3. Forms and reports
4. 3-M Systems
5. SECAS
6. Supply

Security is an important subject for everyone in the Navy. It involves the measures taken to guard against espionage, sabotage, crime, attack, or escape. As Gunner's Mates, our particular concerns are with safeguarding and protecting the sensitive items and materials of our rating. For example, consider the special or nuclear-capable weapons we handle.

Security also extends to all conventional ammunitions, small arms, and related ordnance equipments. Certain publications we use are classified and must not be compromised. Near the end of the chapter, we'll discuss the different security classification designations and their meanings. We'll also examine the security standards related to safeguarding nuclear weapons.

PUBLICATIONS

A publication (pub for short) is a printed work. Usually it is in a book, manual, or binder format, but can assume other styles. Publications are very important sources of information for everyone in the Navy. They are issued by various naval commands or activities. Gunner's Mates are mainly concerned with the technical pubs issued by the Naval Sea Systems Command (NAVSEASYSCOM or NAVSEA). These publications are used to maintain ordnance equipment properly.

NAVSEA is a large and wide-ranging command. It was created some years ago during a reorganization that combined many smaller commands into one. NAVSEA now has control of all pubs formerly issued by these older commands. Although the older commands no longer exist, some of their pubs (and forms) are still in effect. The information they contain has remained valid and you are not in error to use such material. Until NAVSEA rewrites or cancels these pubs, you may still encounter the original command title. Such examples include:

1. Naval Ordnance Systems Command (NAVORD)
2. Naval Ship Systems Command (NAVSHIPS)
3. Bureau of Naval Weapons (NAVWEPS)
4. Bureau of Ordnance (BUORD)

ORDNANCE PUBLICATIONS

The main source of technical information on the operation and maintenance of ordnance equipment is the ordnance publication (OP). You may hear/see an OP also identified as an ordnance pamphlet. Publication or pamphlet... both terms are correct and interchangeable. Most OPs are contained in a snap-ring or swing-hinge binder. This arrangement allows you to remove and replace pages easily.

NAVSEA provides the funding to write, print, and distribute these technical manuals. The writing may be done by the equipment's manufacturer or a commercial pub-writing specialist/company. Sometimes, NAVSEA or another naval activity will do the actual writing. Each OP is assigned a unique identification number (OP number) along with its noun name/equipment nomenclature.

Surface missile system (SMS) OPs are divided into two categories—system OPs and equipment OPs. Another type of OP exists which is called a general OP. Its use is not restricted to the SMS community. General OPs contain information of interest to all ordnance ratings.

System OPs

A system OP describes the physical, functional, operational, and maintenance aspects of a guided missile weapons system. Generally, each class of ship will have its own system OP. The manual's information is specifically tailored to match the configurations and capabilities applicable to a particular class. System OPs are helpful to training commands also. Certain system OPs were used to develop some of the subject matter presented in this rate training manual.

Aboard ship, Fire Controlmen normally take care of the system OPs. These manuals are particularly valuable during system troubleshooting and fault isolation. System OPs can be beneficial to a Gunner's Mate, too. Don't be afraid to consult them.

Equipment OPs

Equipment OPs deal with every aspect of a specific piece of ordnance equipment. Every GMLS has its own OP or set of OPs. These publications will be your primary technical reference source. Get to know them inside and out.

Generally, all equipment OPs are organized in a similar format. Differences do exist, but they are minor. A typical GMLS OP consists of three volumes. If necessary, a volume may be published in two or more parts. This simply reduces the bulk size of a single pamphlet.

Each volume is divided into chapters which address a particular subject area. The chapters are usually subdivided into topic sections and, if required, subsections. Each paragraph of the text is individually numbered. This aids the reader in locating specific information anywhere in the manual.

The OP's material is arranged to follow a natural progression. Early chapters present basic and general information. Later chapters present the more complex and detailed information. This approach gives the reader a solid study foundation for each succeeding chapter.

VOLUME 1.—Volume 1 of a GMLS OP is titled *Description and Operation*. It is divided into five major areas—the front matter and four chapters.

The front matter of the OP consists of the following items:

1. Title page
2. List of effective pages
3. Change record (change page)
4. Foreword
5. Table of contents
6. List of illustrations
7. List of tables
8. List of foldouts (if used)
9. Safety summary

Front matter pages are numbered with Roman numerals (i, ii, v, x, xiv, etc.). The front matter pages should always be arranged in the sequence listed above.

Chapter 1, "Introduction," provides a general overview of the GMLS. Its purposes, capabilities, modes of control, basic physical arrangement, and shipboard location are described. The GMLS's role within the weapons system is explained. If applicable, major model (mod) differences are outlined.

Chapter 2, "Description," provides the detailed physical and functional description of the GMLS. This chapter is the "heart" of Volume 1. Normally, the information is arranged to follow an automatic load-and-fire sequence of equipment operation.

Chapter 3, "Operation," provides step-by-step procedures for operating the GMLS in all modes. These procedures start at system activation and end with securing the equipment after operation. Illustrations show all the electrical control panels of the GMLS. Accompanying tables provide the designations, function, and description of the controls and indicators on each panel.

Chapter 4, "Maintenance," provides brief explanations on the purpose, scope, arrangement, and use of all maintenance procedures. This includes scheduled, unscheduled, and corrective maintenance programs, plus GMLS tests and service materials.

VOLUME 2.—Volume 2 of the GMLS OP is titled *Trouble Isolation*. It is divided into two chapters. Chapter 5, "Troubleshooting," provides the necessary background for the troubleshooting techniques and methods used on the GMLS. Sample (practice) problems are provided and step-by-step procedures to isolate malfunctions are listed.

Chapter 6, "Reference Diagrams," provides the electrical, hydraulic-mechanical, and interconnecting cabling information for the GMLS.

VOLUME 3.—Volume 3 of the GMLS OP is titled *Illustrated Parts Breakdown* (IPB). It has one chapter (chapter 7) that also carries that title. The individual components and assemblies of the GMLS are pictured, identified, and described in the IPB. Virtually every piece of a GMLS is assigned a part number. This number can be used to order/requisition replacement items through the supply system. IPB illustrations also are helpful in disassembling and assembling component parts.

General OPs

The third type of OP is the general OP. It addresses a subject matter area rather than a specific equipment. General OPs do not follow the same format as SMS system and equipment OPs. They are organized in a manner similar to a rate training manual.

General OPs are written and indexed to serve as instruction and training reference sources. *Ammunition Afloat*, NAVSEA OP 4, and *Ammunition Ashore*, NAVSEA OP 5, are two examples of general OPs.

ORDNANCE DATA PUBLICATIONS

Ordnance data publications (ODs) are limited-use technical publications. They serve as a kind of catchall and cover a wide range of subjects. ODs frequently address an equipment installation procedure. Alignment, test, and inspection data are other popular subjects. Sometimes ODs are used to publish advance information on new equipments.

These publications are numbered consecutively by the issuing activity. One OD you should be well acquainted with is *Lubrication of Ordnance Equipment*, NAVSEA OD 3000.

TECHNICAL MANUALS

Technical manuals (TMs) are issued by NAVSEA (formerly NAVSHIPS). They provide very detailed instructions on the installation, operation, and maintenance of certain equipments. Quite often weight, dimensions, machining tolerances/specifications, calibration, and alignment data are included. You may encounter a few TMs, especially those that cover information on auxiliary GMLS equipments (e.g., anti-icing systems).

NAVAL SHIPS' TECHNICAL MANUALS

Naval Ships' Technical Manuals (NSTMs) contain guidance and instructions pertaining to classes of equipment or systems. The information deals with the satisfactory and safe operation, test, and repair of the applicable subject item. An NSTM deals with general information and can provide you with background knowledge. The information also amplifies existing technical manuals and maintenance requirement cards. Chapter 700 of the NSTM series is *Shipboard Ammunition Handling and Stowage.* You may find this particular publication very helpful.

TMINS

The Navy has recently adopted a new type of numbering system to identify its technical publications. The system is called the Standard Technical Manual Identification Numbering System (TMINS). It is designed to eliminate certain problems that existed with the old method of controlling and shipping technical publications.

Eventually, all OPs, ODs, TMs, and so forth, will carry a TMINS number. At this time, only new or newly revised publications are being assigned a TMINS number. Therefore, you will continue to see both the old and new pub numbers until all the manuals are rewritten.

TMINS Number Construction

At first glance, a TMINS number appears long and complicated. In fact, up to 30 alphanumeric characters can be used to construct a TMINS number. Figure 15-1 illustrates the basic format of a TMINS number. Our sample number comes from the Mk 10 GMLS technical manual, SW394-AC-MMA-010/LS10 INDEX.

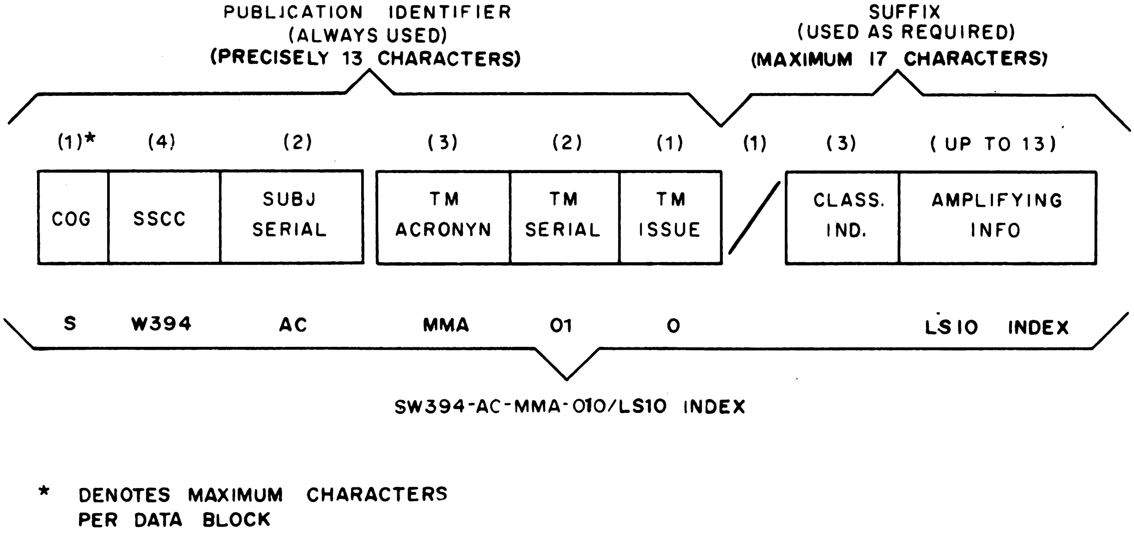
The TMINS number has two main parts—publication identifier (PI) and the suffix. The PI is the essential root of the TMINS number and has six data groups/blocks. The PI is always used and has precisely 13 characters. The suffix has three data groups/blocks and may have as many as 17 characters (maximum). The purpose of each data block is briefly explained below.

1. COG—cognizant code; identifies the manual's cognizant command or who funds/controls it.
2. SSCC—standard subject classification code; identifies the manual's subject category.
3. SUBJ SERIAL—subject serial code; identifies the manual's subject with coded data representing the equipment's nomenclature, usage, location, or numbers (i.e., mark and mod).
4. TM ACRONYM—technical manual (TM) acronym or abbreviation; identifies the type or purpose of the manual.
5. TM SERIAL—TM serial code; identifies a single (complete) TM or the volume/part of a multiset TM. (For example, 01 = first volume, 02 = second volume, and so forth.)
6. TM ISSUE—TM issue code; identifies the manual's change level. (For example, 0 = new or original, A = change 1, B = change 2, and so forth.)
7. /—the "virgule" or slash; it separates PI data from suffix data and is counted as the first character of the suffix.
8. CLASS. IND.—security classification indicator; three-character code (with parentheses) identifying the manual's security level. For unclassified material, the characters are omitted. For classified material, a letter will be enclosed by parentheses. For example, (C) = Confidential, (S) = Secret, (T) = Top Secret, and so forth.
9. AMPLIFYING INFO—amplifying information; a maximum of 13 characters to aid the manual's user identify the subject.

Many of the alphanumeric characters represent special computer-coded data. You can interpret these codes by consulting the publication titled *Description and Application Guide and Index,* MOOOO-OO-IDX-OOO/TMINS.

TMINS Number Translation

Now that you have an idea what a TMINS number is, let's "decode" our Mk 10 GMLS



167.903

Figure 15-1.—TMINS; example.

example. SW394-AC-MMA-010/LS10 INDEX translates to:

S	NAVSEA
W	Weapons/armament/ordnance
394	Guided missile launchers
A	Mk 10 GMLS
C	Third GMLS whose publications were converted to TMINS numbering
MMA	Maintenance manual, all levels
01	First book or binder in the multiset TM
0	Original publication
/LS10 INDEX	The index binder for the Mk 10 GMLS; contains the table of contents, safety summary, and so on

The Mk 10 GMLS technical manual consists of 23 separate binders. (Remember, it is a big GMLS with seven different mods to explain.) The second binder is identified as SW394-AC-MMA-02C/LS10 DES OPR 1. In plain English, this manual is the first part of the description and operation section of the pub. Another binder is SW394-AC-MMA-180/LS10 IPB 4. This translates to the fourth part of the illustrated parts breakdown section. It is also the 18th binder in the set.

As this text was written, certain other publications you may (or will) encounter were converting to TMINS numbering. Although TMINS identification is a bit lengthy, it is designed to provide better service to the fleet. Essentially, a manual's subject matter arrangement did not change. It is still similar to the format of an OP.

PUBLICATION CHANGES

Once in a great while, a publication is written which contains information that remains valid and unchanged for many years. This is the exception rather than the rule. Our technical publications (especially GMLS manuals) are constantly being revised to keep the technicians (us) up to date.

Pub changes reflect new equipment alterations or different policies/procedures. They also correct any errors or discrepancies found in the manual. These problems may be technical in nature or simple printing mistakes. In all cases, the publications we use should be error-free and technically correct, especially where safety is concerned.

Three types of pub changes you should be aware of are: message changes, advance change notices, and format changes.

Message Changes

Message changes (MCs) are issued to correct potentially hazardous conditions resulting from faulty documentation. The safety of personnel, equipment, or ammunition could be at stake. Message changes provide NAVSEA with a rapid means of supplying the fleet with updated information.

If you receive a message change, recognize its urgent nature to correct a hazardous condition. Enter the change in the publication at once, and make all concerned personnel aware of the new information. Frequently, the MC's information will be handwritten into the publication. You may hear this method referred to as a "pen-and-ink" change.

Advance Change Notices

Advance change notices (ACNs) (figure 15-2) are informal, but technically complete pub changes. They are interim (temporary) changes which will be replaced by a formal change in the near future. ACNs do not replace pages in a manual. Generally, the corrections are in pen-and-ink format.

Don't confuse the underlying purposes of message changes and advance change notices. A message change is urgent and safety-related. An ACN is only a routine means of keeping a publication technically up to date.

Formal Changes

Formal changes (CHs) are official replacement pages for a technical manual. They are issued to cover major design changes to the equipment. Formal changes also address minor improvement alterations or an accumulation of corrections. All outstanding message changes, ACNs, plus other technical announcements, will be included in a formal change.

A formal change arrives in a preassembled package. The change may replace a few pages throughout the manual, or it may replace entire sections. A formal change package contains a change guide. The guide provides step-by-step instructions for entering the change pages. Follow these instructions to the letter and work carefully. They are self-explanatory.

Formal changes are numbered consecutively and must be entered into the manual in that order. That means, don't put change 3 into the manual before change 2 has been entered. Additionally, ensure the change applies to your particular equipment configuration. Many times, formal changes are received well in advance of actual equipment alterations. File the change away until the alteration work is accomplished. If you must make changes to a classified publication, be aware that the old pages are still classified. They must be handled properly and destroyed in accordance with existing security regulations.

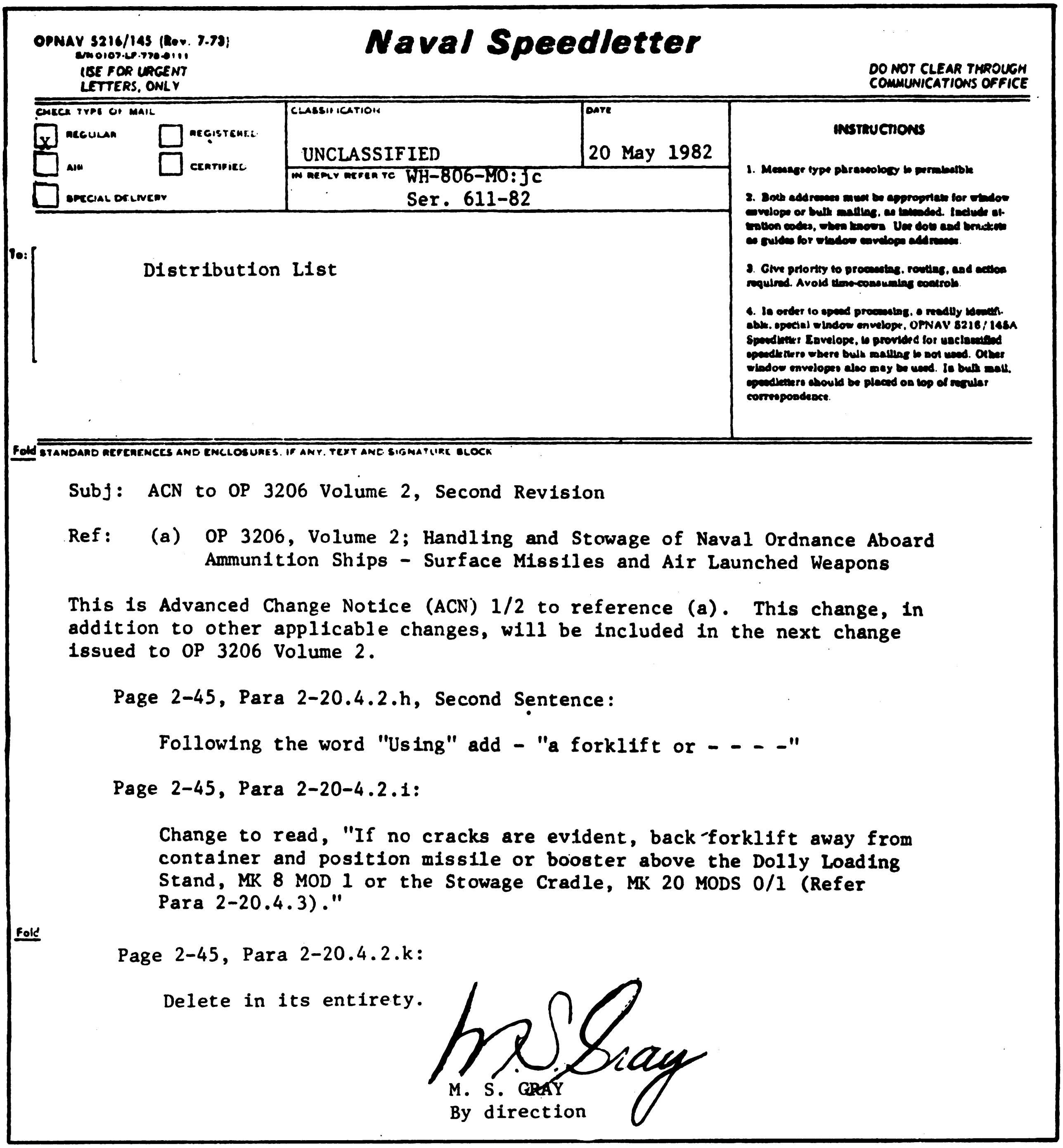
Classified Publications

Some of the technical manuals you must use are classified publications. Much of the information in weapons system OPs comes under the Confidential category. The OPs describing the SMS missiles are Confidential pubs also.

The security measures for handling classified material are covered in OPNAVINST 5510.1F. It is titled the *Department of the Navy Information Security Program Regulation*. Generally, the responsibility for handling classified material involves four main actions.

- Receipt
- Accountability
- Making changes
- Correct distribution

Everyone with access to classified material must be familiar with the instructions in 5510.1F. Use it as the official reference if a question of security arises.



OPNAV 5216/145 (Rev. 7-73)
S/N 0107-LF-778-0111
USE FOR URGENT
LETTERS, ONLY

Naval Speedletter

DO NOT CLEAR THROUGH
COMMUNICATIONS OFFICE

CHECK TYPE OF MAIL

☒ REGULAR
☐ REGISTERED
☐ AIR
☐ CERTIFIED
☐ SPECIAL DELIVERY

CLASSIFICATION: UNCLASSIFIED

DATE: 20 May 1982

IN REPLY REFER TO: WH-806-MO:jc
Ser. 611-82

To: Distribution List

INSTRUCTIONS

1. Message type phraseology is permissible

2. Both addresses must be appropriate for window envelope or bulk mailing, as intended. Include attention codes, when known Use dots and brackets as guides for window envelope addresses.

3. Give priority to processing, routing, and action required. Avoid time-consuming controls.

4. In order to speed processing, a readily identifiable, special window envelope, OPNAV 5216/145A Speedletter Envelope, is provided for unclassified speedletters where bulk mailing is not used. Other window envelopes also may be used. In bulk mail, speedletters should be placed on top of regular correspondence.

Fold STANDARD REFERENCES AND ENCLOSURES, IF ANY, TEXT AND SIGNATURE BLOCK

Subj: ACN to OP 3206 Volume 2, Second Revision

Ref: (a) OP 3206, Volume 2; Handling and Stowage of Naval Ordnance Aboard Ammunition Ships - Surface Missiles and Air Launched Weapons

This is Advanced Change Notice (ACN) 1/2 to reference (a). This change, in addition to other applicable changes, will be included in the next change issued to OP 3206 Volume 2.

Page 2-45, Para 2-20.4.2.h, Second Sentence:

Following the word "Using" add - "a forklift or - - - -"

Page 2-45, Para 2-20-4.2.i:

Change to read, "If no cracks are evident, back forklift away from container and position missile or booster above the Dolly Loading Stand, MK 8 MOD 1 or the Stowage Cradle, MK 20 MODS 0/1 (Refer Para 2-20.4.3)."

Fold

Page 2-45, Para 2-20.4.2.k:

Delete in its entirety.

M S Gray

M. S. GRAY
By direction

83.583

Figure 15-2.—Advance change notice; example.

SPECIAL WEAPONS ORDNANCE PUBLICATIONS

As you know, some of our SMS GMLSs are capable of handling nuclear weapons. All nuclear material used by the armed services is under the control of the DOD's Defense Nuclear Agency (DNA). One of the organizations within the DNA structure is the Joint Nuclear Weapons Publications System. This organization is responsible for providing the armed services with the reference publications concerning nuclear weapons. These publications, known as JNWPs, provide instructions for maintaining, stowing, testing, and identifying such components.

Each branch of the armed services then uses its own designation for the JNWPs. The Army calls them technical manuals (TMs). The Air Force refers to them as technical orders (TOs). In the Navy, we identify them as special weapons ordnance publications or SWOPs.

Navy SWOPs are arranged in a numbered series of publications. The individual manuals within a SWOP series address a specific weapon and its related handling gear and test equipments. For example, the 20 and 50 series of SWOPs describe the handling and stowage requirements for the SMS nuclear weapons.

The importance of a SWOP cannot be stressed enough. SWOPs take precedence over all other technical publications where conflicting information is presented. All action steps or procedures described in SWOPs are mandatory. For these reasons, SWOPs must be maintained meticulously. All received changes must be entered immediately to keep the manual completely and accurately up to date.

You should be familiar with the *Numerical Index to Joint Nuclear Weapons Publications,* NAVY SWOP 0-1. It defines and lists all current and future JNWPs. NAVY SWOP 0-1 is divided into six different parts or sections. Section 2 of NAVY SWOP 0-1, for example, lists all the manuals in the Joint Nuclear Weapons Numbering System. Section 2 also contains various supplements. You should be aware of the information in supplement 0-1B. Supplement 0-1B lists all the publications that pertain to the Navy's nuclear weapons program. In addition to listing the applicable SWOPs, special directives from the CNO, NAVAIR, NAVSEA, and other system commands are included in supplement 0-1B.

Naval Ordnance Station (NOS), McAlester, Okla., is the central inventory and control point for Navy SWOPs. Distribution from NOS, McAlester is performed in accordance with authorized allowance lists. All Navy SWOPs are handled by NOS, McAlester except EODPs (explosive ordnance disposal publications). The EODPs are obtained from the Explosive Ordnance Disposal Facility (EODF), Indian Head, Md.

SMS TECHNICAL BULLETINS

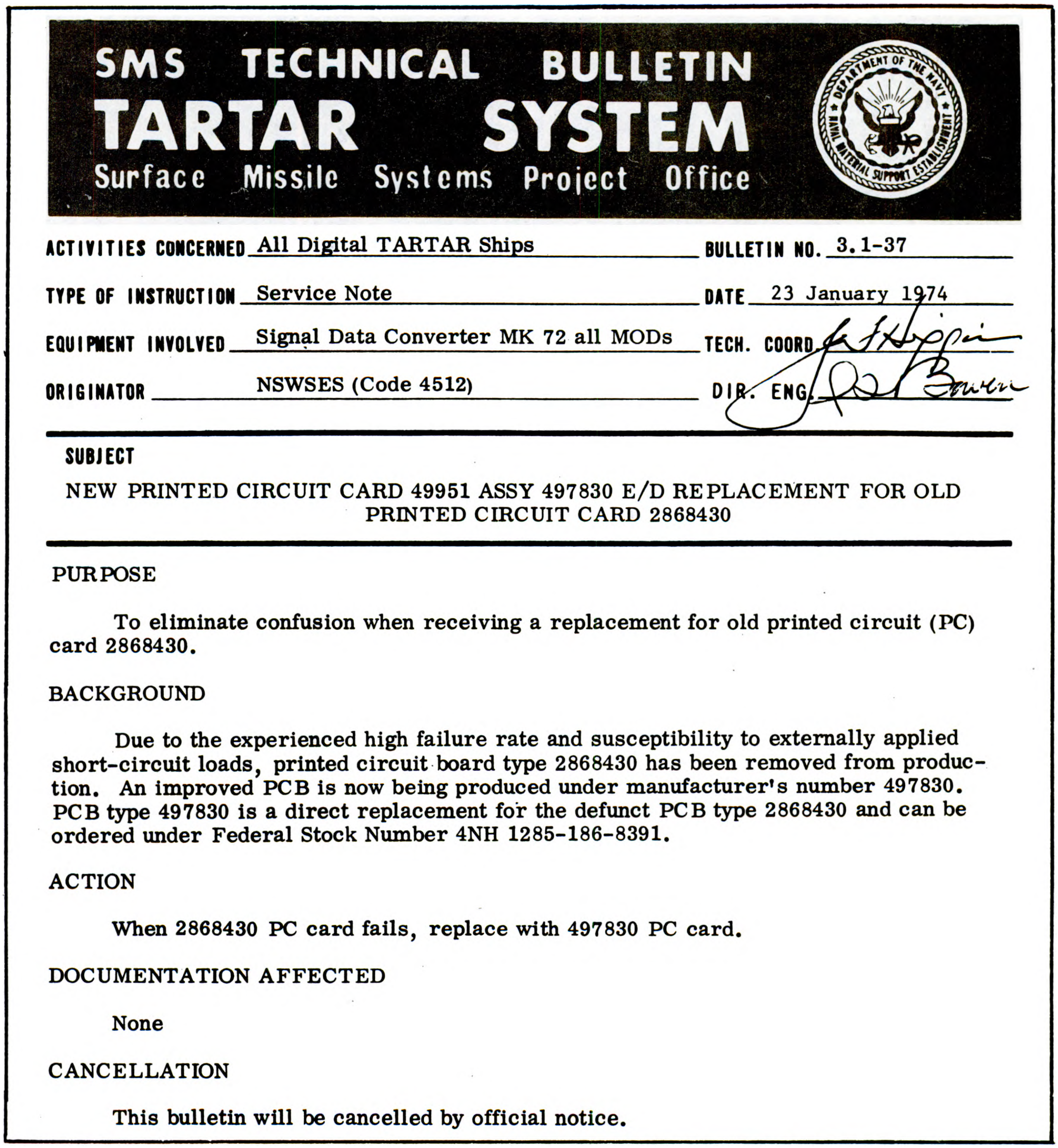
Another publication you should be familiar with is the SMS technical bulletin. A bulletin is a brief notice or announcement issued on an as-required basis. SMS technical bulletins are important sources of information. They provide up-to-the-minute information pertaining to the equipments of a particular weapons system.

For example, Terrier and Tartar systems have their own bulletin data sources. A problem may be discovered or revealed by fleet units, shore activities, or civilian contractors. The equipment involved may be a missile, some piece of FCS gear, or a GMLS. A bulletin is then prepared and issued to all concerned commands. Therefore, you will often hear these notices referred to as Terrier tech bulletins or Tartar tech bulletins.

The information in a bulletin may be as varied as its data sources. A new or revised test procedure may be outlined. Different troubleshooting procedures or adjustment and alignment methods may be described. The bulletin may simply call attention to a technical problem being experienced in the fleet. It also references the use of specific technical manuals to reduce or eliminate a problem. Sometimes a bulletin will note a technical problem for which a solution is being developed.

A majority of the problems addressed by SMS technical bulletins end up as design alternations to the equipment. The bulletin's information is then incorporated into a formal change for the applicable technical manual. Tech bulletins should not be used in place of technical manuals unless so directed.

Figure 15-3 illustrates a typical SMS technical bulletin. Note the format of the information—subject, purpose, background, action, etc. Tech



SMS TECHNICAL BULLETIN
TARTAR SYSTEM
Surface Missile Systems Project Office

DEPARTMENT OF THE NAVY NAVAL MATERIAL SUPPORT ESTABLISHMENT

ACTIVITIES CONCERNED All Digital TARTAR Ships

BULLETIN NO. 3.1-37

TYPE OF INSTRUCTION Service Note

DATE 23 January 1974

EQUIPMENT INVOLVED Signal Data Converter MK 72 all MODs

TECH. COORD

ORIGINATOR NSWSES (Code 4512)

DIR. ENG.

SUBJECT

NEW PRINTED CIRCUIT CARD 49951 ASSY 497830 E/D REPLACEMENT FOR OLD PRINTED CIRCUIT CARD 2868430

PURPOSE

To eliminate confusion when receiving a replacement for old printed circuit (PC) card 2868430.

BACKGROUND

Due to the experienced high failure rate and susceptibility to externally applied short-circuit loads, printed circuit board type 2868430 has been removed from production. An improved PCB is now being produced under manufacturer's number 497830. PCB type 497830 is a direct replacement for the defunct PCB type 2868430 and can be ordered under Federal Stock Number 4NH 1285-186-8391.

ACTION

When 2868430 PC card fails, replace with 497830 PC card.

DOCUMENTATION AFFECTED

None

CANCELLATION

This bulletin will be cancelled by official notice.

83.584

Figure 15-3.—Tartar SMS technical bulletin; example.

bulletins are issued by the Naval Ship Weapon Systems Engineering Station (NSWSES). NSWSES is located at Port Hueneme, Calif., and is NAVSEA's field activity to support the SMS program.

LOGS AND RECORDS

Maintaining logs and records will always be an important part of your military and professional duties. Essentially, these documents provide a written chronological history of an equipment's performance. Information such as operating time, test results, and certain maintenance actions must be recorded. Casualties and repair procedures must be documented also.

Well-kept logs and records serve many purposes and can be useful sources of information. For example, a new GMM reports aboard. The individual can be briefed on the equipment's history by reading the logs and records. Organizations such as NAVSEA and NSWSES routinely receive the information documented in your logs and records. Engineers can study the data and establish an equipment's performance history. Quite often, they can spot potential problem areas and failure trends. The engineers investigate these problems and provide the fleet with recommendations or solutions.

In the ordnance community, you will encounter many different types of logs and records. Usually, the ship's type commander establishes the minimum requirements for recordkeeping. Your chain of command may desire more. Thus, the actual number and types of logs and records you may use can vary among ships. In certain situations, it is better to have too much recorded information than to have too little.

Generally, logs and records can be divided into two categories—rough and smooth. A rough log can be considered an informal type of record. Its information may never leave the work center level and the log can be filled out in pencil. A smooth log is usually a formal type of record. In many cases, its information is a summary of a rough log's data. Smooth log data often leaves the ship and, therefore, it must be neatly printed in ink or typed.

We'll discuss several of the more common types of logs and records used in our rating. On the whole, they are self-explanatory and, with a bit of practice, you will master them quickly.

ROUGH EQUIPMENT LOG

A rough equipment log is an optional form of recordkeeping. Sometimes it is called a rough status or battery log. Entries can cover anything pertaining to the equipment's performance. Such information may include, but is not limited to—

1. any equipment operations—DSOT, exercising, strikedown, missile firings, and so forth.
2. any maintenance actions performed—scheduled and unscheduled preventive or corrective actions.
3. casualties—documenting in detail problem symptoms, troubleshooting steps taken, repairs performed, and so on.
4. test results—documenting any problems experienced, adjustments made, and if readings were in tolerance.

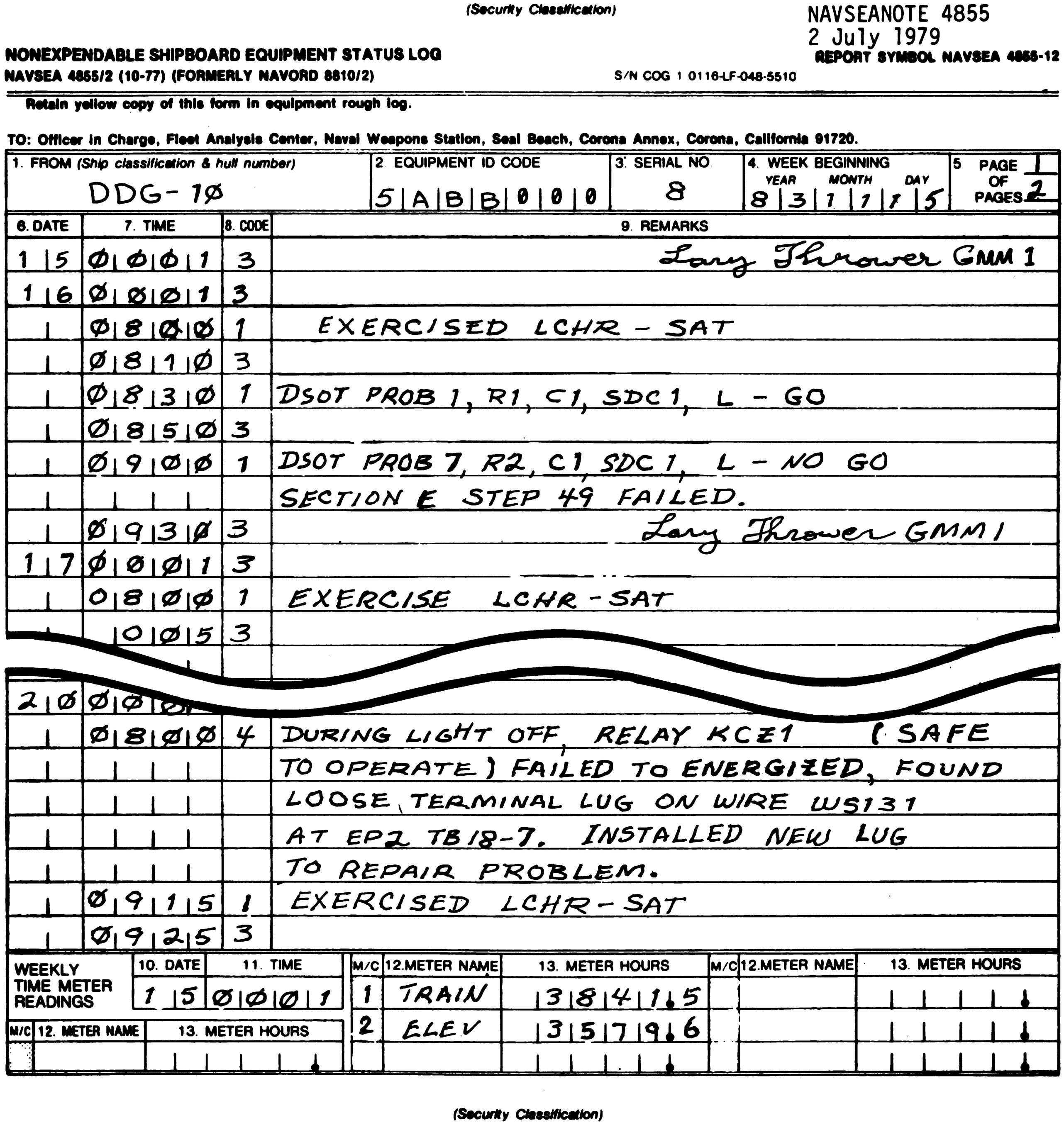
Usually, rough equipment log entries are handwritten (printed) in a notebook-type ledger. All entries should be neat and legible. They should be clearly dated and arranged in an orderly sequence. If desired, event times (starting and stopping) may be recorded also. In many cases, a rough log's format is patterned after a nonexpendable shipboard equipment status log, NAVSEA 4855/2.

The intention of a rough equipment log is just as its name implies. It is a "rough," informal performance record on the equipment. ANY information placed in a rough log should be designed to help you and your work center. Use the log to record handy supply stock numbers, phone numbers, repair tips, and so forth. Penmanship does not count. The quality of the information is more important.

NONEXPENDABLE SHIPBOARD EQUIPMENT STATUS LOG

The nonexpendable shipboard equipment status log (figure 15-4) is officially designated NAVSEA 4855/2. Most people refer to it simply as the "slant two." It is the formal (or smooth) record of an equipment's performance.

NAVSEANOTE (Notice) 4855 (current revision) identifies the equipments that must be reported on this form. Most SMS weapons system equipments, especially the GMLSs, are included in the listing. The recorded data is used to



(Security Classification)

NAVSEANOTE 4855
2 July 1979

NONEXPENDABLE SHIPBOARD EQUIPMENT STATUS LOG
NAVSEA 4855/2 (10-77) (FORMERLY NAVORD 8810/2)

REPORT SYMBOL NAVSEA 4855-12

S/N COG 1 0116-LF-048-5510

Retain yellow copy of this form in equipment rough log.

TO: Officer in Charge, Fleet Analysis Center, Naval Weapons Station, Seal Beach, Corona Annex, Corona, California 91720.

1. FROM (Ship classification & hull number)	2. EQUIPMENT ID CODE	3. SERIAL NO	4. WEEK BEGINNING YEAR MONTH DAY	5 PAGE 1 OF 2 PAGES
DDG-10	5ABB000	8	83 11 15	

6. DATE	7. TIME	8. CODE	9. REMARKS
15	0001	3	Lary Thrower GMM 1
16	0001	3	
	0800	1	EXERCISED LCHR - SAT
	0810	3	
	0830	1	DSOT PROB 1, R1, C1, SDC 1, L - GO
	0850	3	
	0900	1	DSOT PROB 7, R2, C1, SDC 1, L - NO GO
			SECTION E STEP 49 FAILED.
	0930	3	Lary Thrower GMM1
17	0001	3	
	0800	1	EXERCISE LCHR - SAT
	1005	3	
21	00		
	0800	4	DURING LIGHT OFF, RELAY KCZ1 (SAFE
			TO OPERATE) FAILED TO ENERGIZED, FOUND
			LOOSE TERMINAL LUG ON WIRE WS131
			AT EP2 TB18-7. INSTALLED NEW LUG
			TO REPAIR PROBLEM.
	0915	1	EXERCISED LCHR - SAT
	0925	3	

WEEKLY TIME METER READINGS	10. DATE	11. TIME	M/C	12. METER NAME	13. METER HOURS	M/C	12. METER NAME	13. METER HOURS
	15	0001	1	TRAIN	3841.5			
			2	ELEV	3579.6			

M/C	12. METER NAME	13. METER HOURS

(Security Classification)

94.166

Figure 15-4.—Nonexpendable shipboard equipment status log, NAVSEA 4855/2.

assess the overall performance of an equipment/system. These assessments serve as the basis for identifying and correcting equipment deficiencies. Thus, system reliability, maintainability, and availability (RM&A) can be monitored.

NAVSEA 4855/2 forms are available from the supply system and come in a "no carbon required" (NCR) tablet. Handle the form as you would a special request chit. One form actually consists of two pieces of paper—a top white original and a bottom yellow copy. The originals must be forwarded to the Fleet Analysis Center (FLTAC), Corona, Calif., within 7 working days after completion. (The full address is printed on the front of each form.) The original is your formal (or smooth) input to the data reporting system. Be sure it is filled out accurately and neatly. The information can be printed by hand, but use a ballpoint pen, not a pencil.

The yellow copy of the 4855/2 is retained on board. Since it is an exact duplicate of the original, it can serve as the equipment's rough log. IF you can do it right the first time, no other log is required. However, the rough equipment notebook-type log described earlier is still recommended. Why? You can make "mistakes" in your rough log! The 4855/2 should be error-free because it is the official document on the equipment. Use the rough equipment log's entries as a guide to complete the "formal" 4855/2 report.

The information recorded on the 4855/2 should not repeat any 3-M Systems documentation. The form is designed to collect data on an equipment's performance during a 7-day week. This time begins at 0001 hours on a Sunday, and concludes at 2359 hours on the following Saturday. You may use as many forms as necessary to record all the data for the week. Be sure to number the pages, such as page 1 of 2, page 2 of 2, and so on.

Procedures for completing the form are explained in NAVSEANOTE 4855. In figure 15-4, blocks 1 through 5 and 10 through 13 are self-explanatory. Blocks 6 through 9 are the heart of the form. They show the date, time, equipment status code, and amplifying remarks. The status codes are explained in NAVSEANOTE 4855 and are designed to match any equipment condition imaginable. System test results (such as from a DSOT) must be recorded on the 4855/2. Additionally, the equipments used to perform the test must be identified. NAVSEANOTE 4855 recommends the following letter/number codes be used to record that information:

1. PROB 1 or T1—problem 1 or test 1
2. R1 or R2—fire control radar 1 or fire control radar 2
3. C—fire control computer
4. SDC—signal data converter
5. L—GMLS

Make at least one entry at the beginning of each day. The final entry of the day should include the signature of the person completing the form. The security classification of the 4855/2, when filled in, depends upon the type of remarks entered. If there are no classified remarks, the form is unclassified and does not have to be marked. Routine operations such as DSOT, GMLS operations, and strikedown events are not classified information. Stating that a missile was fired is also unclassified. Stating that a missile was fired, then noting the results, is Confidential. The appropriate security classification will be indicated at the top and bottom of the form.

WEAPONS SYSTEM SMOOTH LOG

The weapons system smooth log is usually maintained by the weapons officer. Sometimes it is referred to as the smooth battery log. It serves as the weapons department's official record of important data for all the ship's ordnance equipments.

Although you (personally) may not make any smooth log entries, you should know what type of information is in the log. Several examples are listed below.

1. Installation data (date)
2. Benchmark readings (date)
3. Tram readings (date)
4. Roller path data (date)
5. Drydock data (date)
6. Horizon checks (date)
7. Battery alignment data (date)
8. Radar collimation data (date)

As you can see, much of the information listed above is related to alignment. A weapons system smooth log can be used to compare new readings with older/original readings. If there are substantial differences between the two, a serious problem could be developing and corrective actions should be taken.

SMALL ARMS LOG

Another log you may encounter is the ship's small arms log. It is used to record all pertinent information about the small arms aboard ship. It should list each weapon by type and serial number. The results of inventories and the weapon's location should be noted too. Other log entries can describe any repairs, modifications, or casualties to each weapon.

Consider the small arms log a smooth type of log. Normally, a maintenance history card is kept on each weapon also. This card can be thought of as a rough log. Any pertinent card entries would be transferred to the small arms log.

AMMUNITION LEDGER

The ammunition ledger is a smooth log or record covering the ship's ammunition. It is maintained by the weapons officer or a designated representative. The ledger is used as an accounting record for each type of ammunition carried aboard ship.

All ledger data will be kept on two special forms. They are (1) a Master Stock Record Card, NAVSUP Form 1296, and (2) Ammunition Lot/Location Card, NAVSUP Form 1297. Identifying information, numbers, and receipt and expenditure dates are sample ledger entries. All entries should be posted promptly and made in ballpoint pen.

MAGAZINE LOG

A magazine log is an optional form of recordkeeping. When used, it provides a record of the location and material condition of the ship's magazine areas/compartments. Inspection checkoff lists and the results of magazine inspections should be recorded in this log. Sprinkler system repairs and test results may be included here too.

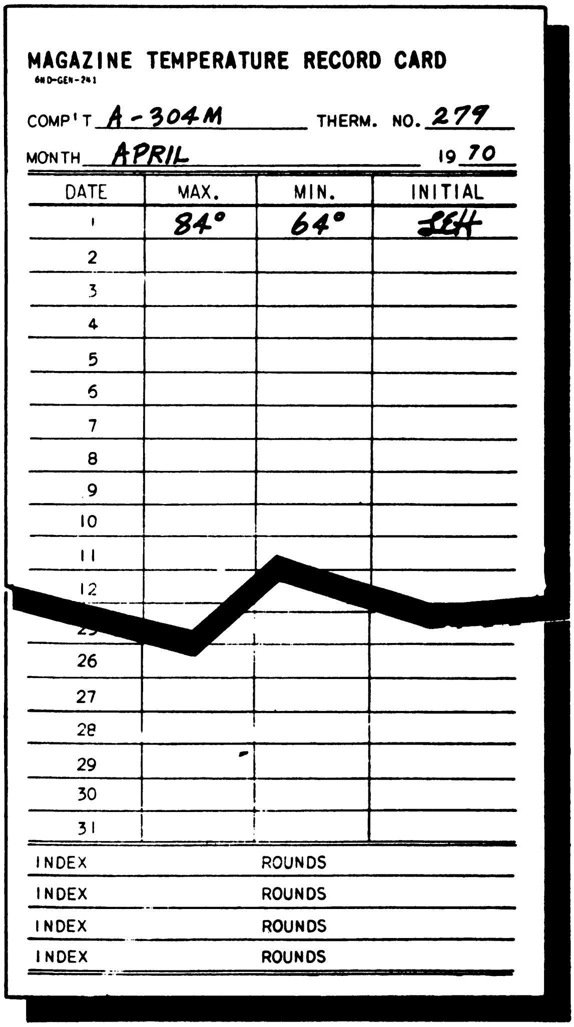
MAGAZINE TEMPERATURE RECORDKEEPING

As mentioned in chapter 14, shipboard magazines must be inspected daily. One of the mandatory items of the inspection is to check and record maximum and minimum space temperatures. (Refer to figure 14-30 of the maximum-minimum bimetallic thermometer.) Four types of logs/records you may use in magazine temperature recordkeeping are listed below:

1. Magazine temperature card
2. Magazine temperature log
3. High temperature notebook
4. Daily magazine temperature report

Magazine Temperature Card

An example of a magazine temperature card is illustrated in figure 15-5. The card is used to



MAGAZINE TEMPERATURE RECORD CARD
6ND-GEN-241

COMP'T A-304M THERM. NO. 279
MONTH APRIL 19 70

DATE	MAX.	MIN.	INITIAL
1	84°	64°	SEH
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
26			
27			
28			
29			
30			
31			

INDEX ROUNDS
INDEX ROUNDS
INDEX ROUNDS
INDEX ROUNDS

220.110

Figure 15-5.—Magazine temperature card.

record the daily maximum and minimum temperatures of a magazine. One card is located in each magazine space and should be mounted next to or near the magazine's thermometer. As you read the thermometer, write the high and low temperatures in the appropriate columns next to the date. Be sure to initial the card at the same time.

On the last day of the month, the card is removed from its holder. A new card for the next month is inserted in its place. The old card is then delivered to the person responsible for maintaining the ship's magazine temperature log. Old (filled in) magazine temperature cards must not be destroyed. Current regulations require they be retained on board for 1 year before they can be discarded.

Magazine Temperature Log

The magazine temperature log is the ship's smooth and permanent chronological record of all magazine temperatures. It is maintained by the weapons officer or a designated representative. The log is filled out once a month. Its entries are obtained from the individual magazine temperature cards.

You should be aware of one special instruction associated with a magazine temperature log. Space temperatures in excess of 100°F must be recorded in a conspicuous (eye-catching) manner (e.g., red ink). An optional entry in this log can include the results of sprinkler system tests.

High Temperature Notebook

The high temperature notebook is a special form of recordkeeping. It is closely related to, but separate from, the magazine temperature log just described. We hope you will never have to use a high temperature notebook.

Smokeless powder, rocket motor, and JATO (jet-assisted-takeoff) magazines require special attention. If temperatures in these spaces exceed 110°F (that is 111°F and greater), extra recordkeeping is necessary. Hourly entries must be made in the high temperature notebook. Only the highest temperature reached that day must be transferred to the magazine temperature log. Naturally, this entry will be in red ink.

If the high temperature notebook must be used, additional entries are required. Be sure to include the following amplifying information: (1) the cause of the rise in temperature (to exceed 110°F), and (2) the measures which were or are being taken to reduce the temperature. Any magazine that constantly has temperatures in excess of 100°F poses a serious problem. Such cases must be reported to proper NAVSEA authority immediately.

Daily Magazine Temperature Report

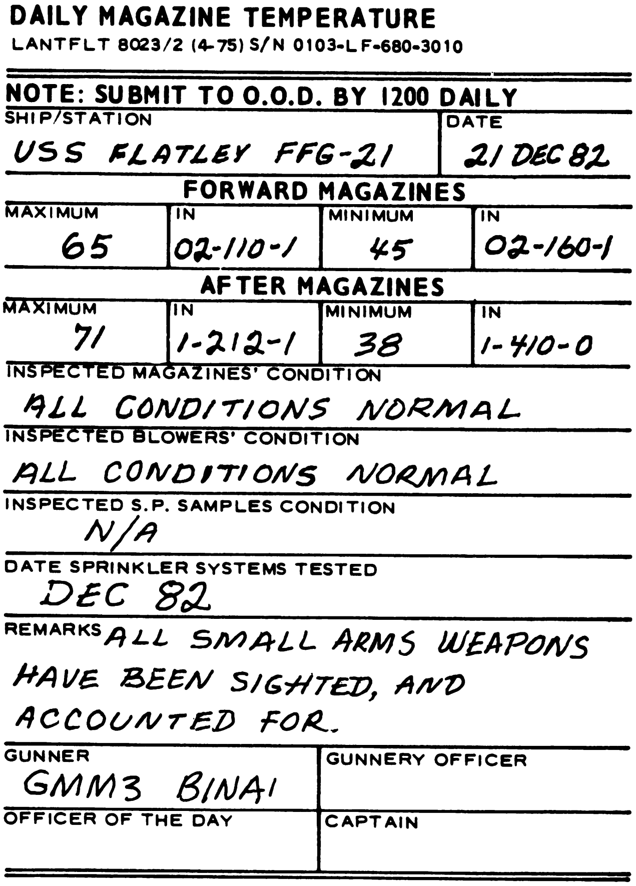
The daily magazine temperature report is an important part of the ship's 12 o'clock reports to the commanding officer. The daily report is filled out after all shipboard magazine temperatures are taken. As duty Gunner's Mate, you are required to take the report to the weapons (or duty weapons) officer for signature. You will then deliver it to the officer of the deck (OOD). The OOD ensures this report (and others) are presented to the commanding officer. If the commanding officer is not aboard, the reports are delivered to the command duty officer (CDO).

The exact format of a daily magazine temperature report may vary between commands. Figure 15-6 illustrates a typical form available through the supply system. In this case, only the highest and lowest readings among all forward and after magazines are required. At another command, the commanding officer may wish to see the maximum and minimum temperatures of each magazine space. These readings would be recorded on a locally prepared form/report.

GUIDED MISSILE SERVICE RECORD

We briefly discussed a guided missile service record (GMSR) in chapter 14. You may also hear/see it referred to as a guided missile log, a missile logbook, or a missile service jacket. In this manual, we will use the term GMSR.

The underlying purpose of a GMSR is to collect maintenance data about a missile. A GMSR is prepared for each missile. Recordkeeping begins at first production and continues until the round is fired or removed from the SMS inventory. When the missile no longer "exists,"



DAILY MAGAZINE TEMPERATURE
LANTFLT 8023/2 (4-75) S/N 0103-LF-680-3010

NOTE: SUBMIT TO O.O.D. BY 1200 DAILY

SHIP/STATION	DATE
USS FLATLEY FFG-21	21 DEC 82

FORWARD MAGAZINES

MAXIMUM	IN	MINIMUM	IN
65	02-110-1	45	02-160-1

AFTER MAGAZINES

MAXIMUM	IN	MINIMUM	IN
71	1-212-1	38	1-410-0

INSPECTED MAGAZINES' CONDITION
ALL CONDITIONS NORMAL

INSPECTED BLOWERS' CONDITION
ALL CONDITIONS NORMAL

INSPECTED S.P. SAMPLES CONDITION
N/A

DATE SPRINKLER SYSTEMS TESTED
DEC 82

REMARKS ALL SMALL ARMS WEAPONS HAVE BEEN SIGHTED, AND ACCOUNTED FOR.

GUNNER	GUNNERY OFFICER
GMM3 BINAI	
OFFICER OF THE DAY	CAPTAIN

Figure 15-6.—Daily magazine temperature report; submitted as part of 12 o'clock reports.

its GMSR is forwarded to the Fleet Analysis Center (FLTAC), Corona, Calif. Parts of the record (pertaining to the propulsion section of the missile) are then forwarded from FLTAC to the Naval Weapons Support Center (NWSC), Crane, Indiana. The data gathered throughout the missile's life-span is analyzed to obtain technical and logistic information. It is also used to determine and improve the reliability, maintainability, and availability (RM&A) of the weapon.

The GMSR is a very important document. It remains with its missile as the round is transferred between different fleet and shore activities. The GMSR must be updated after any maintenance action or significant event occurs to the missile. The majority of record entries will be made by naval weapons station (NWS) personnel. However, shipboard personnel also have some important responsibilities in maintaining a GMSR.

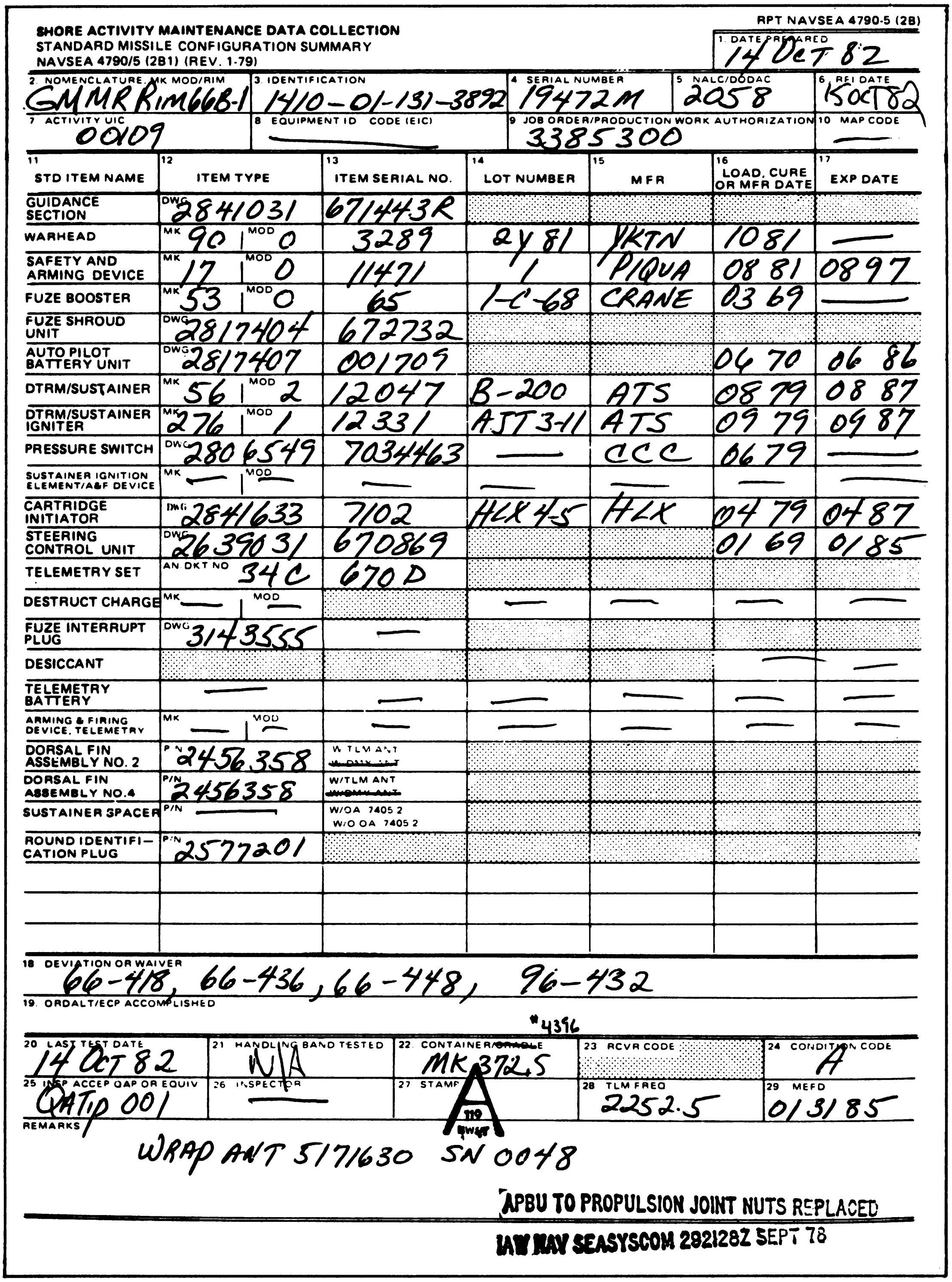
A GMSR consists of the following documents:

1. Missile configuration summary form (CSF)
2. G/M propulsion unit data sheet (PUDS)
3. G/M propulsion unit history sheet (PUHS)
4. Configuration data lists (CDLs)
5. Missile and missile section test traveler cards

The various forms of a GMSR are usually assembled into a clear plastic folder. The folder has left- and right-side pockets or compartments that can be secured with a "zip-loc" type of seal. Listed below is a sampling of the kind of information contained within a GMSR.

1. Dates missile sections were manufactured
2. Missile configuration
3. Last missile test date
4. Ordnance alterations (ORDALTs) accomplished
5. Component service life data
6. Waivers granted
7. Explosive component load dates
8. Explosive material lot numbers

Normally, the ship's missile officer retains custody of the GMSRs on the missiles in your magazine. You may be required to interpret the data and assist in making the appropriate record entries. The following areas of the text describe the basic forms in a GMSR. Our examples are taken from an actual Standard MR GMSR. The forms used in the GMSRs of other missiles are slightly different. However, their purpose is similar. GMSRs are unclassified documents.



RPT NAVSEA 4790-5 (2B)

SHORE ACTIVITY MAINTENANCE DATA COLLECTION
STANDARD MISSILE CONFIGURATION SUMMARY
NAVSEA 4790/5 (2B1) (REV. 1-79)

1. DATE PREPARED: 14 OCT 82

2. NOMENCLATURE, MK MOD/RIM GMMR RIM66B-1	3. IDENTIFICATION 1410-01-131-3892	4. SERIAL NUMBER 19472M	5. NALC/DODAC 2058	6. RFI DATE 15OCT82
7. ACTIVITY UIC 00109	8. EQUIPMENT ID CODE (EIC) —	9. JOB ORDER/PRODUCTION WORK AUTHORIZATION 3385300		10. MAP CODE —

11 STD ITEM NAME	12 ITEM TYPE	13 ITEM SERIAL NO.	14 LOT NUMBER	15 MFR	16 LOAD, CURE OR MFR DATE	17 EXP DATE
GUIDANCE SECTION	DWG 2841031	671443R				
WARHEAD	MK 90 MOD 0	3289	2Y81	YKTN	1081	—
SAFETY AND ARMING DEVICE	MK 17 MOD 0	11471	/	PIQUA	08 81	0897
FUZE BOOSTER	MK 53 MOD 0	65	1-C-68	CRANE	03 69	—
FUZE SHROUD UNIT	DWG 2817404	672732				
AUTO PILOT BATTERY UNIT	DWG 2817407	001709			06 70	06 86
DTRM/SUSTAINER	MK 56 MOD 2	12047	B-200	ATS	08 79	08 87
DTRM/SUSTAINER IGNITER	MK 276 MOD 1	12331	AJT3-11	ATS	09 79	09 87
PRESSURE SWITCH	DWG 2806549	7034463	—	CCC	06 79	—
SUSTAINER IGNITION ELEMENT/A&F DEVICE	MK — MOD —	—	—	—	—	—
CARTRIDGE INITIATOR	DWG 2841633	7102	HLX 4-5	HLX	04 79	04 87
STEERING CONTROL UNIT	DWG 2639031	670869			01 69	01 85
TELEMETRY SET	AN DKT NO 34C	670D				
DESTRUCT CHARGE	MK — MOD —		—	—	—	—
FUZE INTERRUPT PLUG	DWG 3143555	—				
DESICCANT					—	—
TELEMETRY BATTERY	—	—	—	—	—	—
ARMING & FIRING DEVICE, TELEMETRY	MK — MOD —	—	—	—	—	—
DORSAL FIN ASSEMBLY NO. 2	P/N 2456358	W/TLM ANT ~~W/DMY ANT~~				
DORSAL FIN ASSEMBLY NO.4	P/N 2456358	W/TLM ANT ~~W/DMY ANT~~				
SUSTAINER SPACER	P/N —	W/OA 7405 2 W/O OA 7405 2				
ROUND IDENTIFICATION PLUG	P/N 2577201					

18 DEVIATION OR WAIVER: 66-418, 66-436, 66-448, 96-432

19. ORDALT/ECP ACCOMPLISHED: *4396

20 LAST TEST DATE 14 OCT 82	21 HANDLING BAND TESTED N/A	22. CONTAINER/~~CRADLE~~ MK 372.5	23 RCVR CODE	24 CONDITION CODE A
25 INSP ACCEP QAP OR EQUIV QATip 001	26 INSPECTOR —	27 STAMP A 119 RWST	28 TLM FREQ 2252.5	29 MEFD 01 31 85

REMARKS

WRAP ANT 5171630 SN 0048

APBU TO PROPULSION JOINT NUTS REPLACED
IAW NAV SEASYSCOM 292128Z SEPT 78

83.585

Figure 15-7.—Configuration summary form; GMSR.

Configuration Summary Form

The missile configuration summary form (CSF) is the heart of the GMSR. The form is designated NAVSEA 4790/5 (2B1) and contains a wealth of information. A typical CSF is shown in figure 15-7.

The CSF is used to list all the major components installed within a particular missile configuration. Each item is identified by its mark, mod, drawing (DWG), and/or serial numbers. Explosive items have additional data such as lot numbers, load dates, and expiration dates. The CSF also lists the last missile test date, the condition code of the weapon, and the missile expiration firing date (MEFD).

The CSF must be updated/corrected whenever any component of the missile is changed, an ORDALT is accomplished, or a service life is extended. When NWS processing is completed, copies of the missile's CSF are distributed as follows:

1. Original to GMSR

2. Copy to FLTAC

3. Copy to NWSC, Crane

4. Copies to NWS files

G/M Propulsion Unit Data Sheet

The G/M propulsion unit data sheet (PUDS) is the birth certificate of the missile's propulsion unit. The form is designated 9ND-NADC 8821/20. A typical PUDS is shown in figure 15-8. Our example pertains to a Mk 56 DTRM for a Standard MR missile. Missiles that have separate sustainer and booster sections will have two PUDS in their GMSRs. One PUDS applies to the sustainer, the other to the booster. These PUDS are only slightly different from our MR example.

The PUDS is used to record all important data concerning the propulsion unit. This includes manufacturing dates, lot and batch numbers, and appropriate mark, mod, drawing, and/or serial numbers. Waivers, deviations, or other engineering change data must be noted in the "Remarks" section. Service life data and expiration dates are provided also.

The PUDS document remains with the propulsion unit at all times. If the unit is part of a missile, its PUDS will be kept in the GMSR. If the propulsion unit is removed from the missile, the PUDS is removed from the GMSR. Distribution of the PUDS is as follows:

1. Original to GMSR

2. Copy to FLTAC

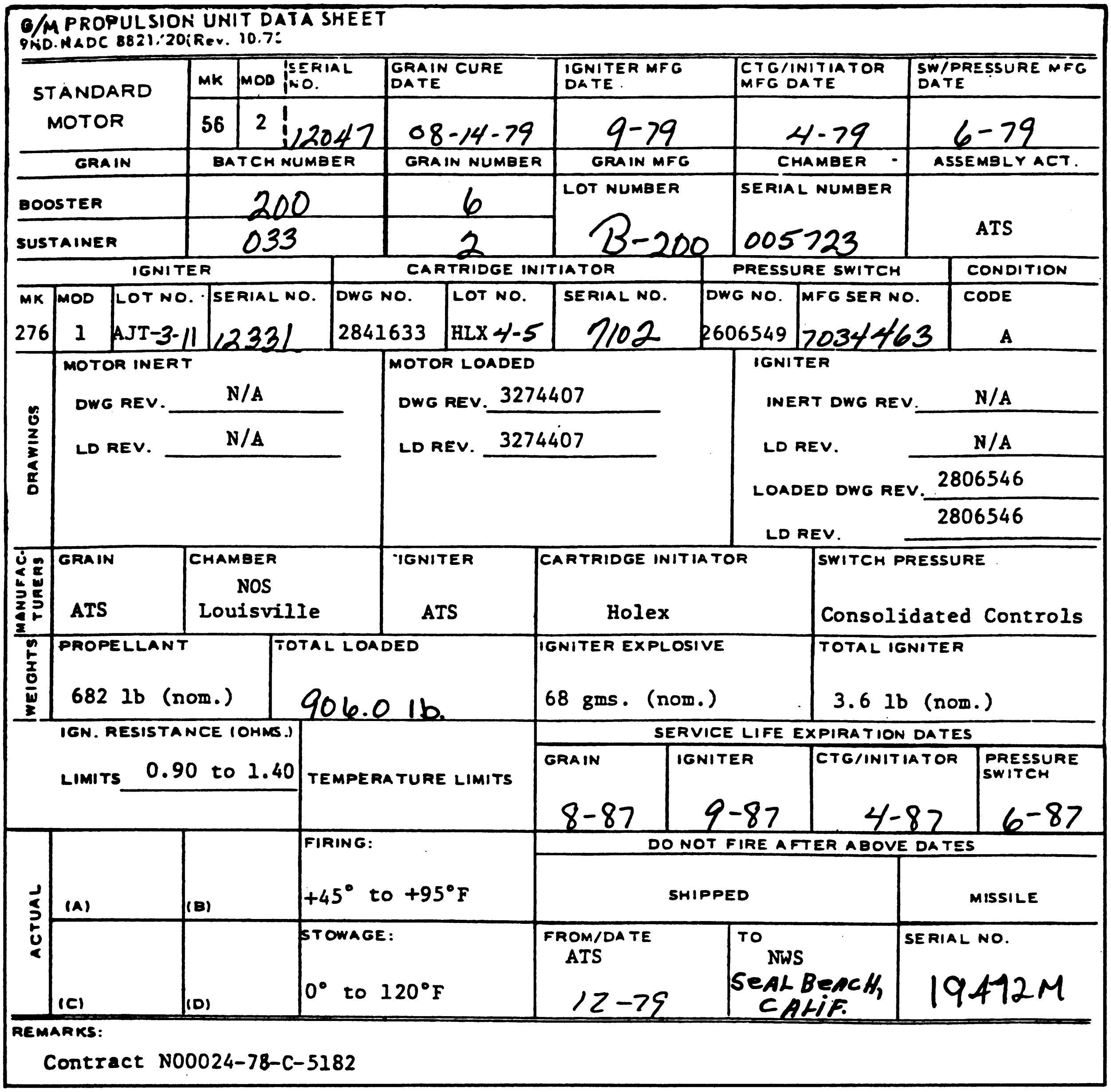
3. Copy to NWSC, Crane

G/M Propulsion Unit History Sheet

The G/M propulsion unit history sheet (PUHS) may be the most important form in the GMSR. It is designated 9ND-NWSCC 8821/9. A typical PUHS is shown in figure 15-9. It is used to document the chronological history of a propulsion unit. For shipboard purposes, the PUHS can be used to make entries regarding the entire missile also.

The results of all NWS propulsion unit inspections, tests, and repairs are documented on the PUHS. Shipboard personnel should record the results of maintenance inspections (especially if a problem is discovered) and missile-to-booster matings (for ER rounds). Receipt and issue (transferred to) data must be included to establish a travel log on the weapon. In some cases, the final entry will be "missile fired," as in our example.

Keep in mind how important the PUHS is. It is the one document in a GMSR that you (aboard ship) MUST maintain. Be sure any details concerning rough handling or unusual environmental exposure are documented. If the weapon has suffered a sprinkler wetdown, state the facts on the PUHS. In short, record ANY significant historical events that occur to the missile.



G/M PROPULSION UNIT DATA SHEET
9ND-NADC 8821/20(Rev. 10.7

STANDARD MOTOR	MK	MOD	SERIAL NO.	GRAIN CURE DATE	IGNITER MFG DATE	CTG/INITIATOR MFG DATE	SW/PRESSURE MFG DATE
	56	2	12047	08-14-79	9-79	4-79	6-79

GRAIN	BATCH NUMBER	GRAIN NUMBER	GRAIN MFG	CHAMBER	ASSEMBLY ACT.
			LOT NUMBER	SERIAL NUMBER	
BOOSTER	200	6	B-200	005723	ATS
SUSTAINER	033	2			

IGNITER				CARTRIDGE INITIATOR			PRESSURE SWITCH		CONDITION
MK	MOD	LOT NO.	SERIAL NO.	DWG NO.	LOT NO.	SERIAL NO.	DWG NO.	MFG SER NO.	CODE
276	1	AJT-3-11	12331	2841633	HLX 4-5	7102	2606549	7034463	A

DRAWINGS	MOTOR INERT	MOTOR LOADED	IGNITER
	DWG REV. N/A	DWG REV. 3274407	INERT DWG REV. N/A
	LD REV. N/A	LD REV. 3274407	LD REV. N/A
			LOADED DWG REV. 2806546
			LD REV. 2806546

MANUFACTURERS	GRAIN	CHAMBER	IGNITER	CARTRIDGE INITIATOR	SWITCH PRESSURE
	ATS	NOS Louisville	ATS	Holex	Consolidated Controls

WEIGHTS	PROPELLANT	TOTAL LOADED	IGNITER EXPLOSIVE	TOTAL IGNITER
	682 lb (nom.)	906.0 lb.	68 gms. (nom.)	3.6 lb (nom.)

IGN. RESISTANCE (OHMS.)	TEMPERATURE LIMITS	SERVICE LIFE EXPIRATION DATES			
		GRAIN	IGNITER	CTG/INITIATOR	PRESSURE SWITCH
LIMITS 0.90 to 1.40		8-87	9-87	4-87	6-87

ACTUAL			TEMPERATURE LIMITS	DO NOT FIRE AFTER ABOVE DATES		
	(A)	(B)	FIRING: +45° to +95°F	SHIPPED		MISSILE
				FROM/DATE	TO	SERIAL NO.
	(C)	(D)	STOWAGE: 0° to 120°F	ATS 12-79	NWS Seal Beach, Calif.	19412M

REMARKS:
Contract N00024-78-C-5182

83.586

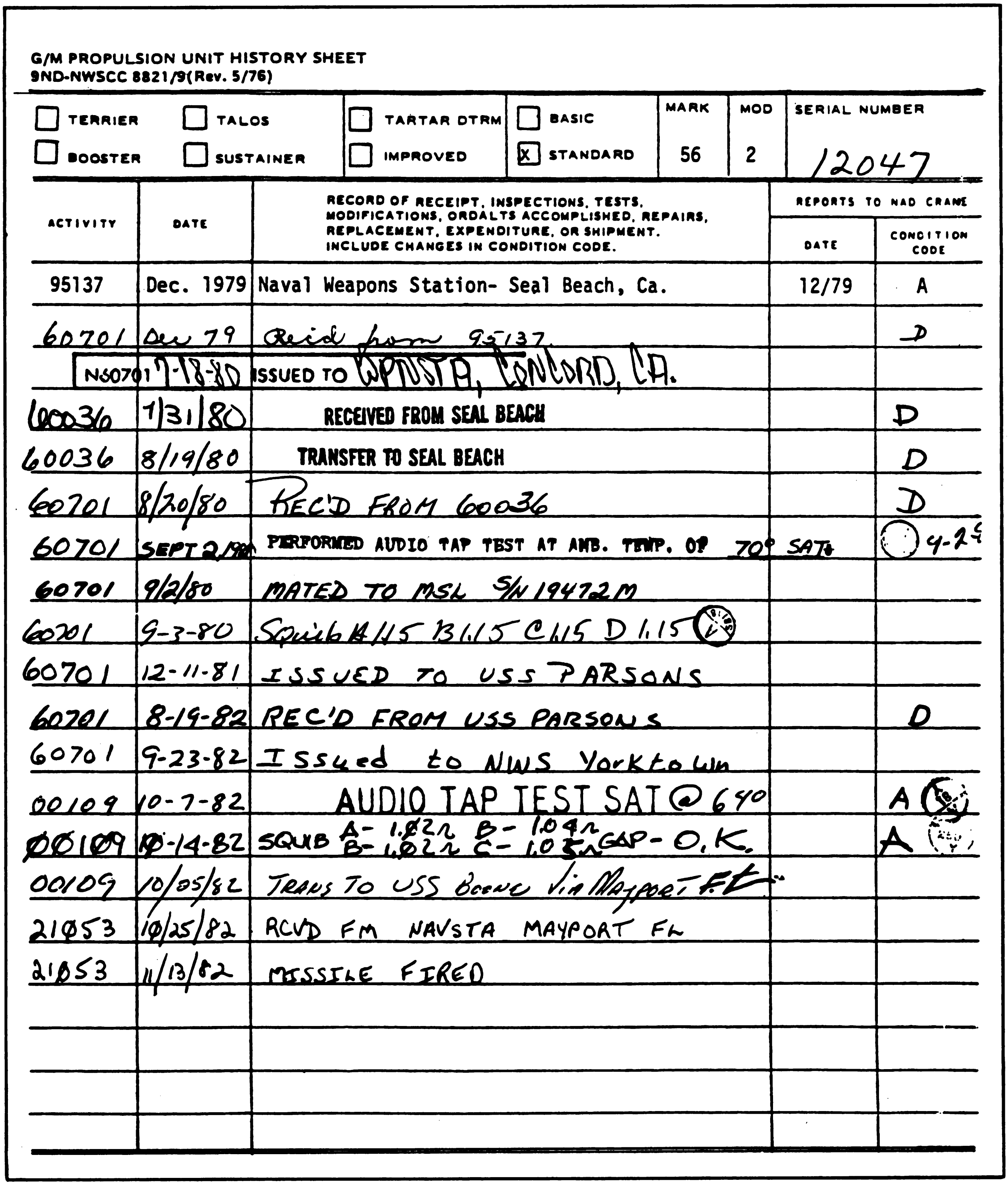
Figure 15-8.—G/M propulsion unit data sheet; GMSR.

The PUHS form remains with the propulsion unit and its importance cannot be stressed enough. The PUHS is distributed as follows:

1. Original to GMSR
2. Copy to FLTAC
3. Copy to NWSC, Crane

Configuration Data Lists

Configuration data lists (CDLs) are the birth certificates for the major sections/units of the missile. The form is designated 27T-163. CDLs are created for a missile's guidance section, fuze shroud unit, autopilot battery unit, and steering



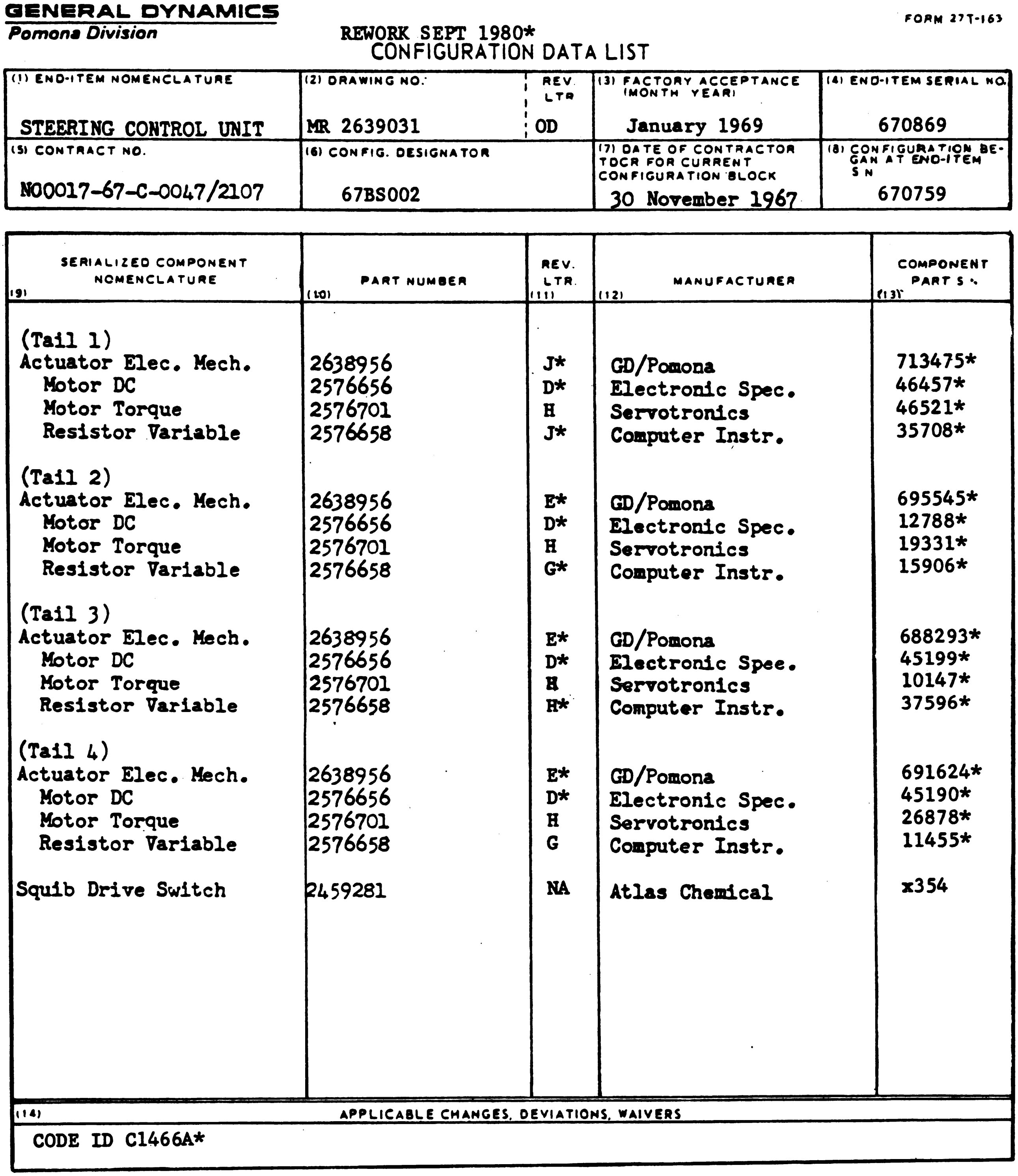
G/M PROPULSION UNIT HISTORY SHEET
9ND-NWSCC 8821/9(Rev. 5/76)

☐ TERRIER	☐ TALOS	☐ TARTAR DTRM	☐ BASIC	MARK	MOD	SERIAL NUMBER
☐ BOOSTER	☐ SUSTAINER	☐ IMPROVED	☒ STANDARD	56	2	12047

ACTIVITY	DATE	RECORD OF RECEIPT, INSPECTIONS, TESTS, MODIFICATIONS, ORDALTS ACCOMPLISHED, REPAIRS, REPLACEMENT, EXPENDITURE, OR SHIPMENT. INCLUDE CHANGES IN CONDITION CODE.	REPORTS TO NAD CRANE DATE	REPORTS TO NAD CRANE CONDITION CODE
95137	Dec. 1979	Naval Weapons Station- Seal Beach, Ca.	12/79	A
60701	Dec 79	Rec'd from 95137		D
N60701	7-18-80	ISSUED TO WPNSTA, CONCORD, CA.		
60036	7/31/80	RECEIVED FROM SEAL BEACH		D
60036	8/19/80	TRANSFER TO SEAL BEACH		D
60701	8/20/80	REC'D FROM 60036		D
60701	SEPT 2,1980	PERFORMED AUDIO TAP TEST AT AMB. TEMP. OF 70° SAT		4-2
60701	9/2/80	MATED TO MSL S/N 19472M		
60701	9-3-80	Squib A1.15 B1.15 C1.15 D1.15		
60701	12-11-81	ISSUED TO USS PARSONS		
60701	8-19-82	REC'D FROM USS PARSONS		D
60701	9-23-82	Issued to NWS Yorktown		
00109	10-7-82	AUDIO TAP TEST SAT @ 64°		A
00109	10-14-82	SQUIB A- 1.02Ω B- 1.04Ω B- 1.02Ω C- 1.05Ω GAP- O.K.		A
00109	10/25/82	TRANS TO USS Boone Via Mayport FL		
21053	10/25/82	RCVD FM NAVSTA MAYPORT FL		
21053	11/13/82	MISSILE FIRED		

83.587

Figure 15-9.—G/M propulsion unit history sheet; GMSR.



GENERAL DYNAMICS
Pomona Division

FORM 27T-163

REWORK SEPT 1980*
CONFIGURATION DATA LIST

(1) END-ITEM NOMENCLATURE STEERING CONTROL UNIT	(2) DRAWING NO. MR 2639031	REV. LTR OD	(3) FACTORY ACCEPTANCE (MONTH YEAR) January 1969	(4) END-ITEM SERIAL NO. 670869
(5) CONTRACT NO. N00017-67-C-0047/2107	(6) CONFIG. DESIGNATOR 67BS002		(7) DATE OF CONTRACTOR TDCR FOR CURRENT CONFIGURATION BLOCK 30 November 1967	(8) CONFIGURATION BEGAN AT END-ITEM S N 670759

SERIALIZED COMPONENT NOMENCLATURE (9)	PART NUMBER (10)	REV. LTR. (11)	MANUFACTURER (12)	COMPONENT PART S N (13)
(Tail 1)				
Actuator Elec. Mech.	2638956	J*	GD/Pomona	713475*
Motor DC	2576656	D*	Electronic Spec.	46457*
Motor Torque	2576701	H	Servotronics	46521*
Resistor Variable	2576658	J*	Computer Instr.	35708*
(Tail 2)				
Actuator Elec. Mech.	2638956	E*	GD/Pomona	695545*
Motor DC	2576656	D*	Electronic Spec.	12788*
Motor Torque	2576701	H	Servotronics	19331*
Resistor Variable	2576658	G*	Computer Instr.	15906*
(Tail 3)				
Actuator Elec. Mech.	2638956	E*	GD/Pomona	688293*
Motor DC	2576656	D*	Electronic Spee.	45199*
Motor Torque	2576701	H	Servotronics	10147*
Resistor Variable	2576658	H*	Computer Instr.	37596*
(Tail 4)				
Actuator Elec. Mech.	2638956	E*	GD/Pomona	691624*
Motor DC	2576656	D*	Electronic Spec.	45190*
Motor Torque	2576701	H	Servotronics	26878*
Resistor Variable	2576658	G	Computer Instr.	11455*
Squib Drive Switch	2459281	NA	Atlas Chemical	x354

(14) APPLICABLE CHANGES, DEVIATIONS, WAIVERS

CODE ID C1466A*

83.588

Figure 15-10.—Configuration data list; GMSR.

control unit. Figure 15-10 illustrates a typical CDL for a steering control unit.

The CDL is provided by the unit's manufacturer. It lists all the major items within a unit by their assigned part number. A block for remarks is used to record any changes, deviations, or waivers made during manufacturer assembly or rework.

The CDLs of a missile remain with the round as part of the GMSR. If a section/unit is disassembled from the missile, its CDL goes with it. CDLs are distributed as follows:

1. Originals to GMSR
2. Copies to FLTAC
3. Copies to NWSC, Crane
4. Copies to NWS files

Test Traveler Cards

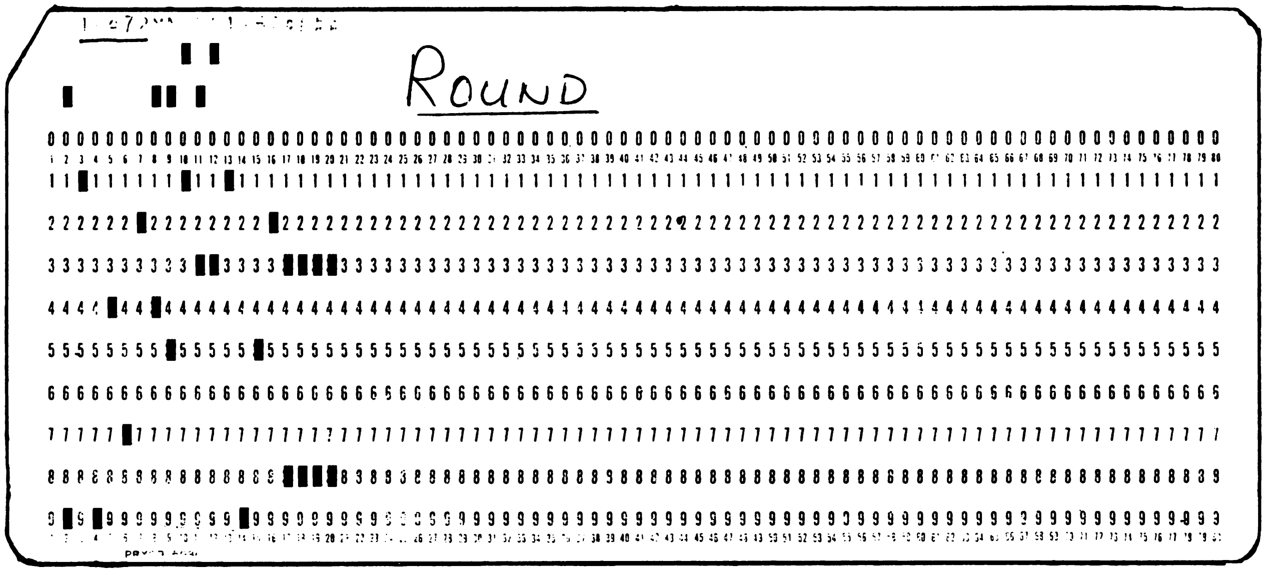
Test traveler cards are provided for each major section of the missile. Additionally, one card is provided for the entire all-up-round (AUR) missile. Test traveler cards are 80-column IBM format computer cards; they are similar to your paycheck. Figure 15-11 illustrates a typical test traveler card for an AUR missile. It contains coded data that identify the round by serial number and configuration.

These cards serve no useful purpose aboard ship, although they must remain with the GMSR. They are used with the AN/DSM 75 and Mk 612 test sets at NWSs. The cards are inserted into the test set and identify the missile's configuration to the test equipments used. The information on the card sets the desired test program and permits testing to be performed.

If a missile is disassembled, the test traveler card for each section/unit "travels" with its component. One final word of caution. Sometimes these cards have a tendency to fall out of a GMSR. Be extra careful not to lose or misplace them.

FORMS AND REPORTS

Forms and reports are somewhat different from logs and records. For our purposes, a form is a printed or typed document. It contains blank spaces for inserting required or requested



83.589

Figure 15-11.—Test traveler card; GMSR.

information. Forms provide the easiest, clearest, and most practical method of gathering and interpreting data. On the other hand, a report is more of an official or formal written statement. It is similar to an essay or narrative story.

Naturally, there are many types of forms and reports in existence. We'll limit our discussion to those you should be aware of at this point in your career.

THE SHIPS' 3-M SYSTEMS

Your first introduction to forms and reports will probably be through the Ships' 3-M Systems. These "systems" are the Planned Maintenance System (PMS) and the Maintenance Data System (MDS).

We will not go into great detail about these systems and their forms and reports. Such information is readily available to you in two other reference sources. A basic overview of the 3-M Systems is in *Military Requirements for Petty Officer 3 & 2,* NAVEDTRA 10056. The complete details of the 3-M Systems are provided in the *Ships' 3-M Manual,* OPNAVINST 4790.4. Pay particular attention to volumes I and II of this three-volume manual. They are the master references for the PMS and MDS respectively.

PMS-Related Forms and Reports

You need to understand certain PMS forms and reports. The more important documents are listed below, followed by a brief explanation.

- List of Effective Pages (LOEP)—The LOEP provides a listing of the maintenance index pages (MIPs) assigned to each work center in a department. It is identified as report number PMS 5.

- Maintenance Index Page (MIP)—The MIP is the basic reference document that identifies the system, subsystem, or component covered by the PMS. It provides a brief description of each maintenance requirement (MR) and lists applicable reference publications.

- Maintenance Requirement Card (MRC)—The MRC provides detailed guidance for accomplishing each MR. It defines the task in simple language and standardizes work procedures. A list of tools and materials needed for the job is included.

- Equipment Guide List (EGL)—The EGL is used with certain MRCs that cover a number of identical equipments (e.g., motors, small arms, and valves). The EGL is prepared by the ship and lists each piece of similar equipment by name, serial number, and shipboard location. Use of the EGL ensures that no equipment is missed or forgotten when an MR is performed.

- Cycle Schedule—It displays the work center's MRs to be performed between major ship overhauls. The department head is responsible for the preparation of the cycle schedule.

- Quarterly Schedule—It displays the work center's MRs to be performed during a specific 3-month period. It also shows the ship's deployment schedule. The department head is responsible for the preparation of the quarterly schedule. The division officer is responsible for updating the quarterly schedule every Monday.

- Weekly Schedule—It shows all the work center's MRs scheduled for completion during a particular week. The division officer supervises the preparation of the schedule and must sign it each week. The work center supervisor is responsible for updating the schedule. Space is provided to assign, by name, individuals responsible for performing the specific MRs scheduled.

- PMS Feedback Report (PMS FBR)—The five-part FBR form is designated as OPNAV 4790/7B. It is used to report on areas related to the PMS and partial source data automation (PSDA). The FBR has two subject categories. Category A is for nontechnical matters and is handled by the appropriate NAVSEA Support Center, Atlantic or Pacific (NAVSEACENLANT or NAVSEACENPAC). Category B is for technical matters and is handled by your TYCOM (type commander).

- Urgent Message FBR—Technical PMS matters involving personnel and equipment safety/damage are reported on an urgent FBR. A naval message should be used to submit the problem.

MDC-Related Forms and Reports

You need to understand certain MDS forms and reports. The more important documents are listed below, followed by a brief explanation.

- Ship's Maintenance Action Form, OPNAV Form 4790/2K—The handwritten "2 Kilo" is used to report all deferred and completed (including previously deferred) maintenance actions.

- Automated Ship's Maintenance Form, OPNAV Form 4790/2Q—The "2Q" is filled in with a special shipboard data processer. A 2Q contains the same information as a 2K.

- Supplemental Form, OPNAV Form 4790/2L—The "2 Lima" is used to provide amplifying information related to a maintenance action reported on a 2K or 2Q. Such information may be a drawing with dimensions, a list of parts, and so forth.

- Maintenance Planning and Estimating Form, OPNAV Form 4790/2P—The "2P" is used with a 2K deferring maintenance to be done by an intermediate maintenance activity (IMA). The 2P is a handwritten document prepared by IMA personnel and includes planning estimates for materials, time, and job costs.

- Automated Work Request, OPNAV 4790/2R—The computer-produced "2R" combines the information from a 2K and 2P, or a 2Q and 2P.

- Ship's Configuration Change Form, OPNAV 4790/CK—The 4790/CK is used to report completed configuration changes at the individual equipment level. A configuration change involves an equipment installation, removal, replacement, relocation, modification, or alteration.

- Internal Ship Supply Issue Document, NAVSUP Form 1250—The 1250 is used by ships that do not have a computer-aided supply management system (nonautomated). It is used to obtain parts to complete a maintenance action. Both supply department and maintenance personnel enter information on this form.

- DOD Single Line Item Requisition System Document, DD Form 1348—The 1348 is used by ships that have a computer-aided supply management system (automated). It is used to obtain parts in the same way as the 1250. Both supply department and maintenance personnel enter information on this form.

- Non-NSN Requisition, DD Form 1348-6—The 1348-6 ("dash 6") is used to obtain parts that cannot be identified with an NSN (national stock number). The dash 6 must be accompanied by a 1250 or 1348.

- Current Ship's Maintenance Project (CSMP)—The CSMP is a computer printout that provides a consolidated listing of deferred maintenance actions. The CSMP is the basic management tool for accomplishing repairs aboard ship. Each work center will receive its own copy of the CSMP.

- Job Control Number (JCN) Log—The work center supervisor will maintain the work center's JCN log. It is used to account for job sequence numbers (JSNs) assigned to maintenance actions.

- Partial Source Data Automation (PSDA)—The hardware of PSDA includes an embossed "credit" card and a mechanical data recorder. The PSDA card contains 2K identification information that does not change. Examples include ship, work center, and equipment names and numbers. Use of the PSDA reduces the amount or writing required to fill out a 2K.

- Selected Equipment Reporting List (SEL)—From time to time, certain items in the fleet are designated "selected equipments." These equipments are new, have proved to be unreliable, or are of special interest to logistic managers. Selected equipments are required to report ALL corrective maintenance actions and repair parts on the standard MDS forms. Selected equipment reporting provides for a comprehensive collection of data in a relatively short period. Equipment part and performance problems are identified quickly so corrective actions/solutions can be initiated.

- Failed Parts Reporting (FPR)—Failed parts reporting is used to identify specific parts/components that actually failed in service. The part's failure directly caused the equipment to be out of commission. Reporting a failed part is very simple and involves checking a box on the 1250, or writing "FPR" in a box on the 1348. That information "flags" the part and results in a special engineering analysis of the item's reliability, design, and so on.

The Ships' 3-M Systems—Summary

Understanding the concepts and tools of the 3-M Systems is important. The PMS and MDS forms and reports briefly described in this text represent only the "tip of the iceberg." Make a special point to study the reference sources mentioned earlier.

CONAR

The quantity of data collected through the PMS, MDS, status log 4855/2, and other documents is obviously immense. However, the need still exists to have an informal means of communication between similar commands throughout the fleet. Thus, the Commanding Officer's Narrative Report (CONAR) was developed.

The CONAR provides a ship the opportunity to comment on its entire combat system as a whole. Recommendations for improved operation can be expressed. Suggestions concerning the best use of manpower and equipment can be made. Problems experienced in quality control, part failures, excessive lead-times (procurement), and test procedures can be stated.

The CONAR should not be used in place of the routine reporting documents (e.g., the PMS FBR); nor should the CONAR be used as a "crying towel." The intent of the CONAR is to uncover and define problems of more than a routine nature. It should be used to evaluate, compare, or simply report problems encountered.

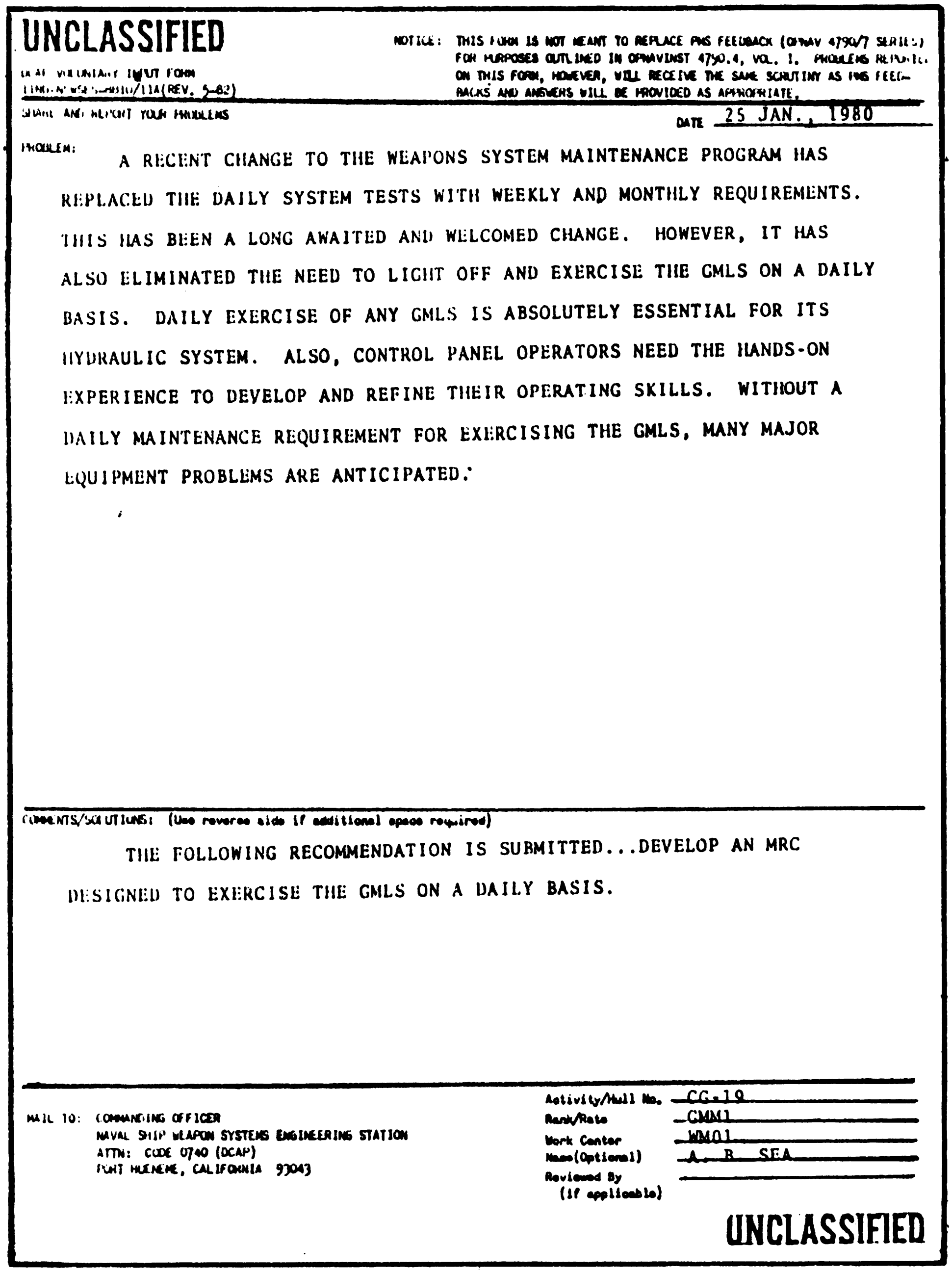
The CONAR is submitted to NSWSES within 15 working days after each calendar quarter. Upon receipt of the CONARs, NSWSES distributes copies to the appropriate NAVSEA activities. Noted problem areas are reviewed and defined. Your ship and all other ships of your class then receive summarized copies of the CONAR. Answers to questions, solutions, or intended actions are provided. Problems relating to personnel manning are referred to the Naval Military Personnel Center (NMPC) for comment.

You may be required to help prepare your work center's CONAR input. Naturally, the GMLS's performance over the last 3 months would be your primary concern. But don't forget the secondary and auxiliary equipments. How often did that TSAM or GMTR break down? Could you get ship's steam or supply air when you needed it? Did you have enough test equipment available? All those "little" things count too. Where can you get such detailed, historic information? How about your rough equipment log or 4855/2 status log (yellow copies)? They are both excellent sources to use when preparing a CONAR.

DCAP

Another valuable means of problem reporting is the Deficiency Corrective Action Program (DCAP). It provides an informal method for fleet technicians to communicate with their civilian counterparts. Problem reporting is done on the DCAP Voluntary Input Form (figure 15-12). Use the form to report on new or recurring problems, to ask about hardware/software problems, to request missing change packages, and to make possible solutions/suggestions. Be sure to provide the maximum identification information available when completing the form. Once the form is filled out, mail it to NSWSES; the correct address is printed on the form.

DCAP-reported problems are reviewed by engineering and logistic personnel at NSWSES, or by other activities when required. The problems are analyzed and solutions are developed. You will receive a reply in the mail. Additionally, your problem and its solution will be shared with the rest of the fleet. On a monthly or quarterly basis, NSWSES prepares and distributes DCAP status reports. They are an accumulation of problem inputs and subsequent solutions. A separate DCAP status report is issued for each equipment family (e.g., Tartar, Terrier, Aegis, Harpoon,



UNCLASSIFIED

DCAP VOLUNTARY INPUT FORM
[illegible]/11A(REV. 5-82)

NOTICE: THIS FORM IS NOT MEANT TO REPLACE PMS FEEDBACK (OPNAV 4790/7 SERIES) FOR PURPOSES OUTLINED IN OPNAVINST 4790.4, VOL. I. PROBLEMS REPORTED ON THIS FORM, HOWEVER, WILL RECEIVE THE SAME SCRUTINY AS PMS FEEDBACKS AND ANSWERS WILL BE PROVIDED AS APPROPRIATE.

SHARE AND REPORT YOUR PROBLEMS

DATE 25 JAN., 1980

PROBLEM:

A RECENT CHANGE TO THE WEAPONS SYSTEM MAINTENANCE PROGRAM HAS REPLACED THE DAILY SYSTEM TESTS WITH WEEKLY AND MONTHLY REQUIREMENTS. THIS HAS BEEN A LONG AWAITED AND WELCOMED CHANGE. HOWEVER, IT HAS ALSO ELIMINATED THE NEED TO LIGHT OFF AND EXERCISE THE GMLS ON A DAILY BASIS. DAILY EXERCISE OF ANY GMLS IS ABSOLUTELY ESSENTIAL FOR ITS HYDRAULIC SYSTEM. ALSO, CONTROL PANEL OPERATORS NEED THE HANDS-ON EXPERIENCE TO DEVELOP AND REFINE THEIR OPERATING SKILLS. WITHOUT A DAILY MAINTENANCE REQUIREMENT FOR EXERCISING THE GMLS, MANY MAJOR EQUIPMENT PROBLEMS ARE ANTICIPATED.

COMMENTS/SOLUTIONS: (Use reverse side if additional space required)

THE FOLLOWING RECOMMENDATION IS SUBMITTED...DEVELOP AN MRC DESIGNED TO EXERCISE THE GMLS ON A DAILY BASIS.

MAIL TO: COMMANDING OFFICER
NAVAL SHIP WEAPON SYSTEMS ENGINEERING STATION
ATTN: CODE 0740 (DCAP)
PORT HUENEME, CALIFORNIA 93043

Activity/Hull No. CG-19
Rank/Rate CMM1
Work Center WM01
Name(Optional) A. B. SEA
Reviewed By (if applicable) ______

UNCLASSIFIED

Figure 15-12.—DCAP voluntary input form.

and so forth). Figure 15-13 illustrates a typical DCAP status report page.

PAPERWORK POINTERS

We have discussed a multitude of logs, records, forms, and reports. What did all these "paperwork" items have in common? Basically, they were WRITTEN documents. You cannot hide from the need to write. It is as much a part of your job as is running a DSOT or onloading a missile.

As you advance, you will be required to do more writing. You do NOT have to be an English major or a paperwork genius to do an effective job. Filling out forms and writing reports is not that hard. But it does take practice, experience, and some degree of concentration.

Listed below are a few helpful tips or "pointers" regarding paperwork in general. If you apply them, it could make your job easier.

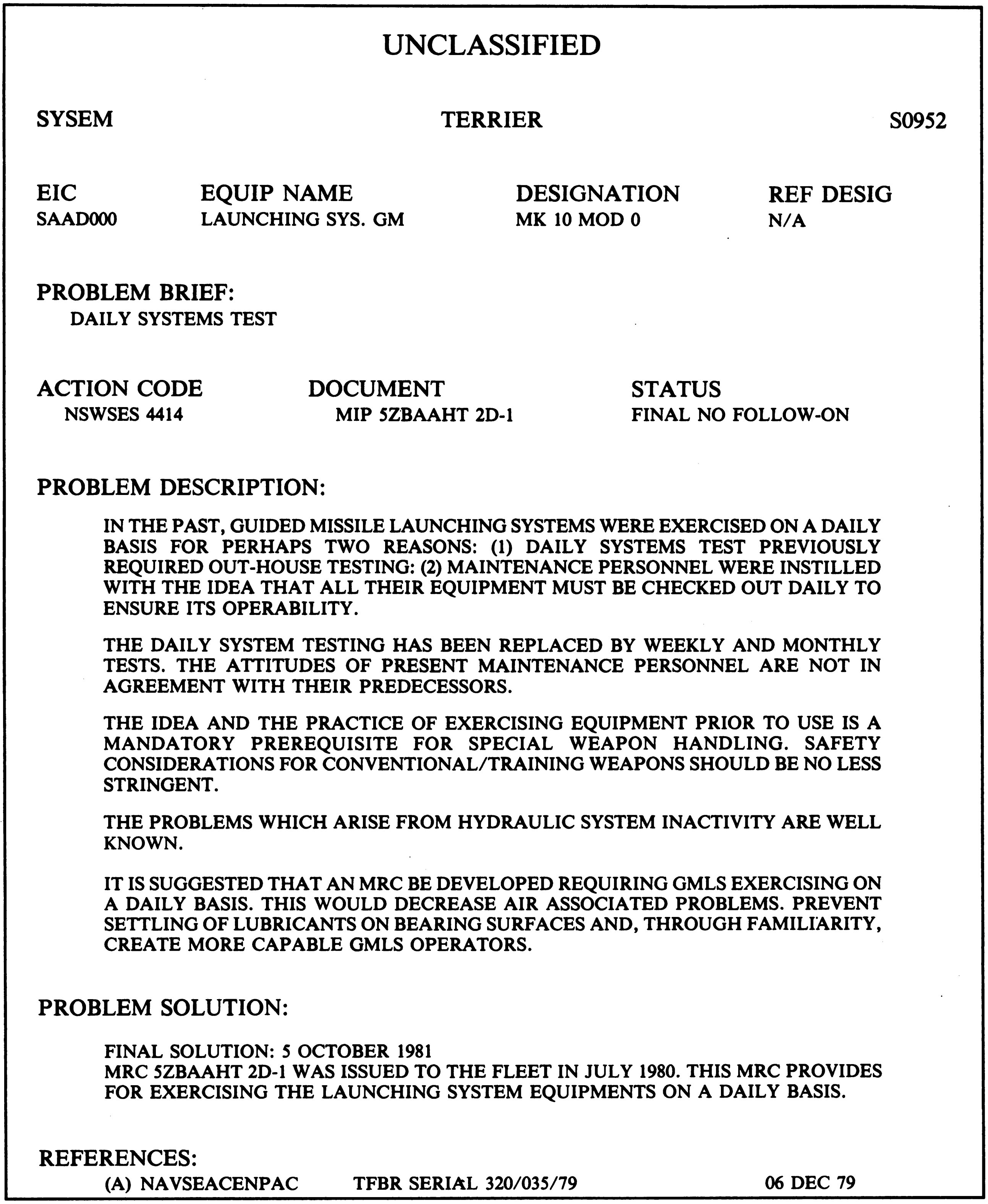
- Understand the purpose of the form or report.
- Organize your thoughts; use an outline or rough notes as a guide.
- Come to the point; don't ramble.
- Introduce a new subject area briefly.
- Make your sentences and thoughts flow together.
- Keep your language clear, concise, and simple.
- Use smaller words in place of larger, more complicated terms: accomplish = do; approximately = about; utilize = use.
- Use a dictionary!
- Be neat!
- Doublecheck your facts.
- Be technically accurate, especially with numbers.
- Provide enough information so the reader isn't left "hanging" or in doubt.
- Follow a proven example/sample.
- Take a break after you have written something and then come back to the work refreshed; reread, then revise or rewrite.
- Turn paperwork in on time.
- Look for ways to reduce paperwork.
- Ask for help.
- Take pride in your work and always do your best.

ALTERATIONS

Any authorized change to the ship's hull, machinery, equipment, or fittings is called an alteration. It can involve revisions to the design, materials, number, or location of such items. Alterations which affect the military characteristics of a ship are called NAVALTs. They must be approved by the Chief of Naval Operations (CNO). Alterations other than NAVALTs are approved by the appropriate/cognizant systems command (NAVAIR, NAVELEX, NAVSEA, and the like). Generally, these changes affect matters of safety, efficiency, and economy of operation or upkeep.

In the SMS community, you will deal with two types of alterations—SHIPALTs and ORDALTs. Normally, they are intended to (1) increase an equipment's performance capability and/or (2) correct a deficiency.

Design and technical engineers are responsible for creating these alterations. In many cases, they get "ideas" from their years of personal experience working with the equipment. However, don't forget all those logs and reports you completed. You documented the problems you found working with the equipment daily. The point is, what you say on paper does count and your inputs often result in needed alterations and improvements.



UNCLASSIFIED

SYSEM TERRIER S0952

EIC	EQUIP NAME	DESIGNATION	REF DESIG
SAAD000	LAUNCHING SYS. GM	MK 10 MOD 0	N/A

PROBLEM BRIEF:
DAILY SYSTEMS TEST

ACTION CODE	DOCUMENT	STATUS
NSWSES 4414	MIP 5ZBAAHT 2D-1	FINAL NO FOLLOW-ON

PROBLEM DESCRIPTION:

IN THE PAST, GUIDED MISSILE LAUNCHING SYSTEMS WERE EXERCISED ON A DAILY BASIS FOR PERHAPS TWO REASONS: (1) DAILY SYSTEMS TEST PREVIOUSLY REQUIRED OUT-HOUSE TESTING: (2) MAINTENANCE PERSONNEL WERE INSTILLED WITH THE IDEA THAT ALL THEIR EQUIPMENT MUST BE CHECKED OUT DAILY TO ENSURE ITS OPERABILITY.

THE DAILY SYSTEM TESTING HAS BEEN REPLACED BY WEEKLY AND MONTHLY TESTS. THE ATTITUDES OF PRESENT MAINTENANCE PERSONNEL ARE NOT IN AGREEMENT WITH THEIR PREDECESSORS.

THE IDEA AND THE PRACTICE OF EXERCISING EQUIPMENT PRIOR TO USE IS A MANDATORY PREREQUISITE FOR SPECIAL WEAPON HANDLING. SAFETY CONSIDERATIONS FOR CONVENTIONAL/TRAINING WEAPONS SHOULD BE NO LESS STRINGENT.

THE PROBLEMS WHICH ARISE FROM HYDRAULIC SYSTEM INACTIVITY ARE WELL KNOWN.

IT IS SUGGESTED THAT AN MRC BE DEVELOPED REQUIRING GMLS EXERCISING ON A DAILY BASIS. THIS WOULD DECREASE AIR ASSOCIATED PROBLEMS. PREVENT SETTLING OF LUBRICANTS ON BEARING SURFACES AND, THROUGH FAMILIARITY, CREATE MORE CAPABLE GMLS OPERATORS.

PROBLEM SOLUTION:

FINAL SOLUTION: 5 OCTOBER 1981
MRC 5ZBAAHT 2D-1 WAS ISSUED TO THE FLEET IN JULY 1980. THIS MRC PROVIDES FOR EXERCISING THE LAUNCHING SYSTEM EQUIPMENTS ON A DAILY BASIS.

REFERENCES:
(A) NAVSEACENPAC TFBR SERIAL 320/035/79 06 DEC 79

Figure 15-13.—DCAP status report page.

SHIPALTS

Approved alterations to shipboard machinery and equipments under the cognizance of NAVSEASYSCOM are called SHIPALTs. SHIPALTs do not (directly) affect ordnance equipment. However, you will have SHIPALT work performed on your gear. Confusing? The confusion is a result of the fact that certain items associated with a GMLS are not "true" ordnance equipments.

For example, air-conditioning and anti-icing systems are altered/modified by SHIPALTs. The GMLS's fire suppression systems fall within the SHIPALT category. Strikedown gear and dud-jettison supply bank flasks are SHIPALT items also. Remember, these component groups are the secondary and auxiliary equipments of a GMLS.

The ship's engineering office maintains the master file of SHIPALT instructions pertaining to your command. When a SHIPALT instruction is received, you should submit a deferred maintenance action form (4790/2K or 2Q). That places the alteration on your CSMP. Check the master file occasionally to ensure all your SHIPALTs are documented and entered on the CSMP.

ORDALTS

Approved alterations to ordnance equipments under the cognizance of NAVSEASYSCOM are called ORDALTs. They are numbered consecutively without regard to equipment or ship class. An ORDALT (OA) number may have three, four, or five digits, such as OA 999, OA 8204, and OA 10,123.

The two basic parts to any ORDALT package are (1) the instruction and (2) the kit. ORDALT instructions are mailed to concerned activities well in advance of a scheduled installation. When you receive an ORDALT instruction, study it carefully. Information is provided which explains why the change is being made, how to do it, and (very importantly) who will do the work. At the same time, submit your 4790/2K or 2Q to put the job on the CSMP.

The ORDALT kit is the material or hardware needed for the alteration. The kit contains everything (except common handtools) required to complete the job. ORDALT kits are usually stocked at central issue points. The Naval Weapons Support Center at Crane, Indiana, and NSWSES are two such activities.

NAVSEA Support Centers (LANT and PAC) are assigned the responsibility for ORDALT completion and verification. When and where the ORDALT is to be installed and who will do the work vary. The size and complexity of the job are considered. How long the equipment must be out of commission, manpower involved, and costs are other planning factors.

When it is feasible to do so, ships are brought up to a particular ORDALT configuration/status during shipyard overhaul or repair availabilities (RAVs). Generally, manpower and time are less restricted during these periods. Shipyard workers, IMA, tender, and ship's force personnel may be assigned the work. NAVSEACEN personnel assist, supervise, quality control, and verify ORDALT accomplishment.

Occasionally, simple and quick ORDALTs or those marked "urgent" or "emergency" may be installed while the ship is pierside. Ship's force, assisted and verified by NAVSEACEN personnel, may do all the work. Kits for these types of ORDALTs usually can be ordered through the supply system. Consult the ORDALT's instruction to obtain the kit's NSN and fill out your 1250 or 1348.

After an ORDALT is installed and checked out, two very important jobs must be done. First, a metal ORDALT plate is attached to each major piece of ordnance equipment. You must stamp the number of the completed ORDALT onto the plate. This serves as the permanent ORDALT accomplishment record for the gear. Administrative reports can get lost and people do get transferred, but the ORDALT plate remains. The second task that must be done is to submit a 4790/CK, Ship's Configuration Change Form. That leads us to our next two subjects—SECAS and SAIL.

SECAS

SECAS stands for Ship Equipment Configuration Accounting System. In simple terms, it is an enormous data collecting system. SECAS is an invaluable administrative tool for the Navy's operational and logistic managers. Briefly summarized, SECAS—

1. identifies all shipboard systems, equipments, and components.
2. locates all identified items.
3. records all associated data.
4. verifies accomplishment of specific engineering changes (SHIPALTs, ORDALTs, and so on).
5. distributes collected data to concerned engineering activities, supply support activities, and operational (project) managers.

The configuration data accumulated through SECAS is provided to various agencies in support of—

1. technical publications.
2. PMS requirements.
3. test equipment requirements.
4. training course requirements.
5. onboard repair part support.
6. the Weapons Systems File.

The Weapons Systems File (WSF) is maintained at the Navy Ships Parts Control Center (SPCC) in Mechanicsburg, Pa. The WSF is the central control data bank for ordnance equipment configuration information. The WSF receives initial or updated configuration information through a variety of sources. These reporting sources include—

1. new ship and equipment acquisition programs.
2. shipboard validations.
3. pre- and post-shipyard overhaul reports (the SAIL primarily).
4. MDS forms (4790/CK primarily and the 4790/2K in some cases).

So, what does SECAS do for you? Think back to ORDALTs. We said you had to submit a 4790/CK (an MDS/SECAS reporting form) when an ORDALT was accomplished. The 4790/CK tells our equipment's project and logistic managers that the gear has just changed. To support that change, we need new/more test equipment and repair parts carried on board. We need new/updated technical publications, PMS requirements, and so on.

Therefore, SECAS makes possible better logistic and maintenance support for the installed shipboard equipment. But, SECAS can't work for us if it is not kept up to date on current equipment configuration. That's why it is so important for you to submit forms like the 4790/CK. The SAIL is another SECAS reporting document you will encounter.

SAIL

SAIL stands for Ship Armament Installation List and is officially identified as SECAS Report E0010. (SAIL was formerly known as the Ship Armament "Inventory" List; the term "Installation" is correct.) It provides SECAS with the configuration status of all shipboard nonexpendable ordnance systems and equipments, including applicable ORDALTs.

Table 15-1 explains the major headings used on a SAIL. Figure 15-14 shows one page of a typical/actual SAIL. Use table 15-1 to interpret the SAIL in figure 15-14.

SECAS provides copies of a ship's SAIL to NAVSEA and all other concerned activities. Periodically, you must review and update your equipment's SAIL data. A marked-up copy of the SAIL is sent to the WSF at SPCC. Here, it is reprinted and redistributed as required. Updating/correcting your SAIL is particularly important before and immediately after a scheduled shipyard overhaul. Normally, many equipment alterations are accomplished during this period. The SAIL reflects the current configuration status of your equipment. It is your responsibility to keep it up to date.

SUPPLY

Considering all the administrative duties that must be done, supply may be THE most important. It's hard to imagine maintaining a GMLS work center without supplies. The work center supervisor must take an active part in supply administration. You will be required to help.

The ship's supply department is responsible for supporting the material needs of the command. That means procuring the items

Table 15-1.—SAIL Data

HEADING	EXPLANATION/REMARKS
PRODUCT ID	The product reference number.
VESSEL NAME	The name of a ship, activity, etc.
SQDRN/DIV	The ship's squadron/division number.
REASON FOR ISSUE	The reason for issuing the SAIL (i.e., the scheduled event: new construction, overhaul, etc. or Special Request.)
TYCOM	The administrative command for this class of ship.
TYPE/HULL	Ship Type—A designation for a class of ship. Ship Hull—An identity/serial number for a specific ship in a class of ships.
PROTO	The design prototype hull number after which the ship was constructed and registered.
UIC	The accounting number identifying a ship or activity (NAVCOMPT Manual 161.2 Vol. 2 Ch 5 applies).
AVAILABILITY DATE	The data the ship is to be available for alteration/modification or the scheduled event defined in the Reason for Issue (blank for Special Request).
O/H YARD	The shipyard where the scheduled event is to take place.
REPORT DATA	The date the Ship Armament Installation List (SAIL) was prepared.
NAVSEA TYPE DESK	NAVSEASYSCOM HQ organization responsible for ship maintenance.
CAN	The Configuration Accounting Number is an item code for systems/equipment of a ship/shore activity that: 1) identifies the cognizant ISEA of the item and 2) establishes the order in which the item is listed in the Ship Armament Installation List.
SYS/EQ NOMENCLATURE	A brief name designation for the standard nomenclature assigned by the NAVSEA Program Manager for the system/equipment on board.
NOMENCLATURE CODE	A code used for ADP purposes to represent the name of the system/equipment (system codes have three significant numbers, equipment codes have four).
MARK	A particular subcategory of an item having the same basic concept/function as the item identified by the nomenclature code.
MOD	A particular modification to an item identified by nomenclature name/code and Mark (i.e., not affecting interchangeability).
SERIAL	A brief item identification number defining a specific system/equipment.
P	The position of the item relative to adjacent and associated equipment (e.g., Left, Right, or Center).
LOCATION	The location of ordnance systems aboard a ship/activity (e.g., Deck/Frame/Compartment or Mount No).
ORDALT DATA ACCOMPLISHED/ UNACCOMPLISHED	The status of the listed ORDALT defined be the heading under which is appears.
NUMBER	The ORDALT number. A unique document idenfication number that directs and authorizes an alteration to ordnance systems/equipment.
R	A revised and completely new issue to an existing ORDALT instruction.
C	A text correction, addition, or deletion to an existing ORDALT instruction.
SET	Identifies which of several sets or ORDALT kits and documents are applicable to a given use (the prefix "P" to a set no. may be used to identify an ORDALT kit as applicable to more than one equipment within the system to which it applies).
K	Ordnance alteration key. Identifies ORDALT action/status in relation to the item modified.
DATE	Ordnance alteration accomplishment date, year and month the ORDALT was accomplished.

SHIPS ARMAMENT INSTALLATION LIST

PRODUCT ID: E0010 VESSEL NAME: OLIVER HAZARD PERRY SQDRN/DIV: 012

REASON FOR ISSUE: SEMI-ANNUAL UPDATE TYCOM: COMNAVSURFLANT TYPE/HULL: FFG 0007 PROTO: 0007 UIC: 21028

AVAILABILITY DATE: O/H YARD: REPORT DATE: 4 FEB 82 NAVSEA TYPE DESK 931

								ORDALT DATA											
								ACCOMPLISHED						UNACCOMPLISHED					
CAN	SYS/EQ NOMENCLATURE	CODE	MARK	MOD	SERIAL	P	LOCATION	NUMBER	R	C	SET	K	DATE	NUMBER	R	C	SET	K	STATUS
N080	MISSILE EQPT. MISC	820	0		R40														
N081	MISSILE, TRAINING ROUND	8366	60	4	SA350									10627				A	3
N082	SIMULATOR	7770	63	4	7461									9923				A	3
														10636				A	3
N100	LAUNCHING SYS. GM	210	13	4	42			8810	1			D	-						
								9272				D	-						
								9280				A	79-02						
								9442				A	79-02						
								9499				A	-	9537				A	4
														9661				A	4
														9662				A	4
														9663				A	4
														9736				A	4
														9795				A	3
														9840				A	4
														9962				A	3
N110	FIRE CONTROL SYSTEM	51	82	2	3														

Figure 15-14.—SAIL; example.

necessary to keep the equipment maintained and operating. These items include:

- Repair parts—Manufactured or replaceable items or assemblies for a piece of machinery or equipment. Virtually everything in a GMLS is a repair part.

- Repairable items—Components or items that can be returned to an operable condition by use of repair parts or overhaul. A PC card is an example of a repairable item.

- Consumable items—Administrative and housekeeping supplies, routine maintenance tools, and general purpose hardware. Pens, pencils, forms, sponges, rags, cleaning solvent, greases, and handtools are consumables.

- Equipage—Items of a durable nature that are not consumed in use and are essential to the ship's mission. Does not include installed equipment. Typewriters, portable power tools, and life preservers are equipage items.

- Controlled equipage—Selected equipage items which require increased management control due to high cost, easy theft, and so on. Binoculars, certain test equipment, and stopwatches are designated controlled equipage.

The basic mechanics of supply have already been explained in *Military Requirements for Petty Officer 3 & 2.* The *Ships' 3-M Manual,* OPNAVINST 4790.4, provides detailed information on supply requisition forms. The *Storekeeper 3 & 2,* NAVEDTRA 10269, can be another excellent (optional) reference source for you. Be sure to consult these publications. We'll only "hit the high points" in this manual.

ORDERING A REPAIR PART

Let's assume the hydraulic interlock valve assembly shown in figure 15-15 in the GMLS has developed a minor leak. Replacing/renewing its packings and gaskets will correct the problem. Your job—get the parts.

The following areas of the text will trace the general steps required to get those repair parts. This is a "rough" description only. Certain details have been omitted and the sequences of our example can be varied.

Sources of Identification

First step—identify the part(s) needed. For GMLS repair parts, the system's *Illustrated Parts Breakdown* (IPB) publication is the normal source for such information. (The IPB was described earlier under "Publications.")

Figure 15-15 shows a typical IPB page format. Study it for a moment; it is self-explanatory. A lot of information can be obtained from the IPB, including component arrangement/relationship, dimensions, sizes, and quantities. Most important, however, the IPB lists the manufacturer's identifying (or part) number for each component. To repair our leaking interlock valve assembly (in figure 15-15), we will need index numbers 3, 9, and 11. (Note that packings #3 and #9 are identical.) You should submit 1250/1348 supply requisition forms for (1) "MS2877-215, packing, 6 each," and (2) "734913-39, gasket, 3 each."

There are other sources of information available which can help you identify the parts or materials needed to make a repair. One such example is a part's nameplate (if installed). Nameplate data usually include the manufacturer's name, location, and a DOD contract number. The equipment's mark, model, serial, and lot numbers, plus voltage ratings, dimensions, and so on, may be given also.

If you want handtools, consult the *Afloat Shopping Guide* (ASG). It is very similar to a Sears or J.C. Penney catalog. Another handy reference is the *GSA Supply Catalog* issued by the General Services Administration. It lists many consumable items for general nonmilitary and civil agency use. Need a pillow? Consult the GSA catalog.

Coordinated Shipboard Allowance List (COSAL)

Next step—cross the part numbers to national stock numbers (NSNs). The supply system deals in numbers, specifically NSNs. To order repair parts, we must cross our manufacturer's/IPB

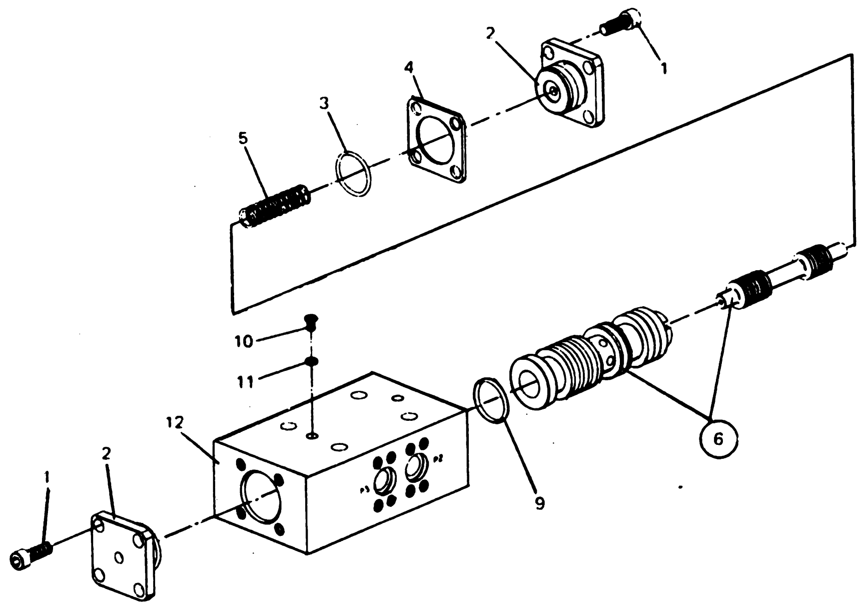


Figure 574. Interlock Valve Assembly

Figure & Index No.	Identifying Number	Name & Description 1 2 3 4 5 6 7	Qty in Assy	Usable on		
				Mk	Mod	Code
574	LD 586836 Dwg 2097759	INTERLOCK VALVE ASSEMBLY . . . . (See Figures 573-863, 576-825, 595-943, 658-856, 659-820, 662-919 for NHA)	-		7,8	
● -1	1611200-64	. CAPSCREW, Self-locking sch, ... 5/16-18 by 7/8 inch	8			
● -2	2097760	. COVER	2			
● -3	MS28775-215	. PACKING, Preformed, 1-1/16 ID x 1/8	2			
● -4	1531386	. SHIM	1			
● -5	1529657	. SPRING, Detent	1			
● -6	LD 614415-12	. PLUNGER AND SLEEVE ASSEMBLY (Spare unit)	1			
-7	*2097761	. . SLEEVE	1			
-8	*2097762	. . PLUNGER	1			
● -9	MS28775-215	. PACKING, Preformed, 1-1/16 ID x 1/8	4			
● -10	734913-19	. PLUG, Valve, No. 10-32 by 9/32 inch	3			
● -11	734913-39	. GASKET	3			
● -12	2097763	. BLOCK, Valve	1			

*Parts not to be requisitioned, use next higher assembly.

83.590

Figure 15-15.—IPB page format; typical.

numbers into NSNs. The primary tool for this task is the ship's Coordinated Shipboard Allowance List (COSAL). The COSAL is a complete listing of all operating equipment and equipage aboard ship. It is divided into three major parts.

Part I of the COSAL is called the Summary of Effective Allowance Parts/Equipage Lists (SOEAPL). It is a summary listing or master index of all onboard equipment and equipage by their assigned APL and AEL numbers. An Allowance Parts List (APL) contains technical data and provides a list of the repair parts required to maintain an equipment. An Allowance Equipage List (AEL) describes the range and quantity of equipage items needed by the ship.

Part II of the COSAL is the most important part for us. It contains the actual APL and AEL pages or sections. Figure 15-16 shows a sample APL page. The supply department will maintain the ship's master COSAL. However, you may obtain copies of the APLs and AELs applicable to your equipment. We recommend you place them in a notebook and retain them in your work center for use as a handy reference.

Part III of the COSAL is of greatest use to the Storekeeper. It provides the final authorized onboard allowance quantity for repair parts. Items common to more than one equipment/department are totaled in this section also.

Back to our leaking interlock valve example. We have obtained the part numbers from the IPB. Now, we can cross those part numbers to NSNs by using an APL from part II of the COSAL.

Did you notice our sample APL page in figure 15-16 was for an ORDALT kit/modification to a particular launcher? Remember, an ORDALT was an example of a configuration change. A 4790/CK had to be submitted and the SAIL updated after the ORDALT was accomplished. These reports went into the WSF at SPCC. COSALs are created and revised by keeping the WSF informed. The end result is better supply support to reflect current equipment configuration status.

Filling Out the Paperwork

The next step or series of steps required in the process of ordering a part is to prepare the necessary supply requisition form(s). The details of how to complete the 1250 or 1348 are explained in *Military Requirements for Petty Officer 3 & 2* and the *Ships' 3-M Manual*. Basically, the work is divided between you and the Storekeepers.

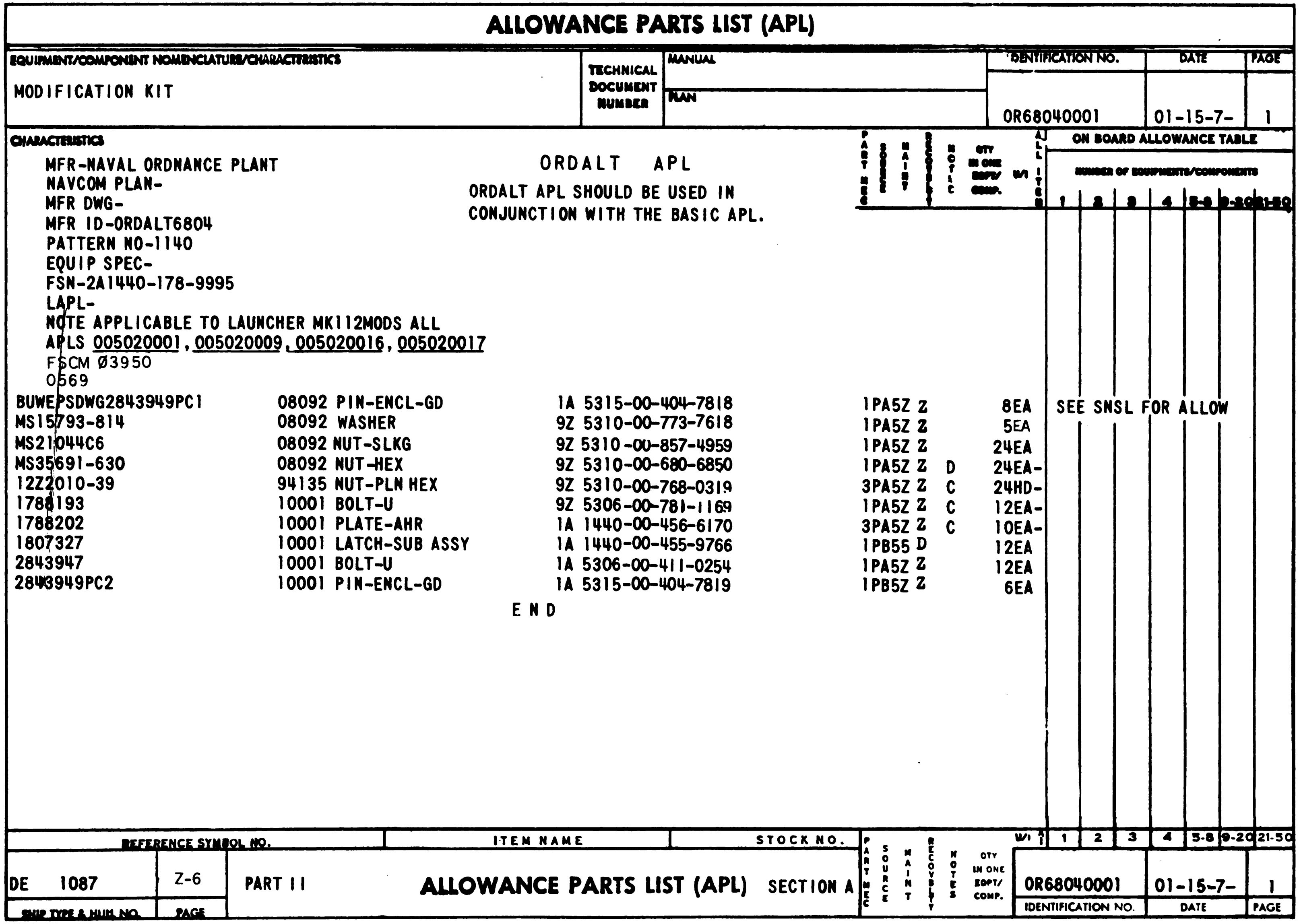
You must enter the information related to the part. Noun name, equipment APL, JCN, EIC, NSN, unit of issue (U/I), and quantity are such examples. Don't forget to check or fill in the FPR block if appropriate. Normally, the weapons officer must sign the requisition form. That signature means permission is granted to spend the department's money. Sometimes, signature authority is given to the division officer, chief, or work center supervisor. Usually they'll have dollar limit. Don't "forge" this important signature or you might end up in hot water!

The remaining blocks of the requisition form are completed by the Storekeepers. They will enter information such as unit price, extended (total) price, fund codes, and so on. Additionally, they will do a stock check. The item you want will be either (1) on board, (2) not in stock (NIS), or (3) not carried (N/C). If the item is on board, it will be in one of the ship's supply storerooms. The Storekeeper will make the "breakout" and issue the part. Urgent parts are issued immediately; routine parts might take a day or two. The person receiving the part must sign for it on the requisition form. If the item is NIS or N/C, the part is placed "on order." The supply department prepares the proper documentation and sends the requisition off the ship. When the part is received, you are notified and issued your order.

Regarding our leaking interlock valve assembly, let's say all the parts (packings and gaskets) were on board. You were issued these parts and completed the repair job. What is left to do administratively? Fill out a completed maintenance action form (4790/2K or 2Q) and submit it. This form documents your equipment problem and other information (such as man-hours expended) to the MDS reporting system. Don't forget to make the rough equipment log and/or 4855/2 entries.

Supply Log

We recommend your work center establish and maintain a supply log. This is a "rough" type of log usually contained in a ledger or notebook. Sometimes, a similar log will be maintained



ALLOWANCE PARTS LIST (APL)

EQUIPMENT/COMPONENT NOMENCLATURE/CHARACTERISTICS	TECHNICAL DOCUMENT NUMBER	MANUAL / PLAN	IDENTIFICATION NO.	DATE	PAGE
MODIFICATION KIT			0R68040001	01-15-7-	1

CHARACTERISTICS

MFR-NAVAL ORDNANCE PLANT
NAVCOM PLAN-
MFR DWG-
MFR ID-ORDALT6804
PATTERN NO-1140
EQUIP SPEC-
FSN-2A1440-178-9995
LAPL-
NOTE APPLICABLE TO LAUNCHER MK112MODS ALL
APLS 005020001, 005020009, 005020016, 005020017
FSCM Ø3950
0569

ORDALT APL

ORDALT APL SHOULD BE USED IN
CONJUNCTION WITH THE BASIC APL.

REFERENCE SYMBOL NO.	ITEM NAME	STOCK NO.	PART NEC / SOURCE / MAINT / RECOVBL'TY	NOTES	QTY IN ONE EQPT/ COMP.	ON BOARD ALLOWANCE TABLE
BUWEPSDWG2843949PC1	08092 PIN-ENCL-GD	1A 5315-00-404-7818	1PA5Z Z		8EA	SEE SNSL FOR ALLOW
MS15793-814	08092 WASHER	9Z 5310-00-773-7618	1PA5Z Z		5EA	
MS21044C6	08092 NUT-SLKG	9Z 5310-00-857-4959	1PA5Z Z		24EA	
MS35691-630	08092 NUT-HEX	9Z 5310-00-680-6850	1PA5Z Z	D	24EA-	
12Z2010-39	94135 NUT-PLN HEX	9Z 5310-00-768-0319	3PA5Z Z	C	24HD-	
1788193	10001 BOLT-U	9Z 5306-00-781-1169	1PA5Z Z	C	12EA-	
1788202	10001 PLATE-AHR	1A 1440-00-456-6170	3PA5Z Z	C	10EA-	
1807327	10001 LATCH-SUB ASSY	1A 1440-00-455-9766	1PB55 D		12EA	
2843947	10001 BOLT-U	1A 5306-00-411-0254	1PA5Z Z		12EA	
2843949PC2	10001 PIN-ENCL-GD	1A 5315-00-404-7819	1PB5Z Z		6EA	

END

NUMBER OF EQUIPMENTS/COMPONENTS: W/I | 1 | 2 | 3 | 4 | 5-8 | 9-20 | 21-50

SHIP TYPE & HULL NO.	PAGE			IDENTIFICATION NO.	DATE	PAGE
DE 1087	Z-6	PART II	ALLOWANCE PARTS LIST (APL) SECTION A	0R68040001	01-15-7-	1

17.63

Figure 15-16.—APL; example.

at the divisional and/or departmental levels also.

The work center's supply log provides a handy reference for keeping track of and accounting for all ordered supply parts. In many cases, it may duplicate the information required on the requisition form. This data can include, but is not limited to—

1. dates ordered and received.
2. JCN.
3. NSN and part number.
4. quantity and price.
5. "remarks" section.
6. requisition number.

If the part you need must be placed on order, the requisition number becomes very important. Every supply ordering document leaving the ship is assigned a unique requisition number. This number is used to identify, account for, and trace the status of ordered parts. You may hear a requisition number called a MILSTRIP number also.

Repairable Items

An important function of the Navy's supply system is its repairable or mandatory turn-in program. Understanding the purpose of the program and your part in it will be helpful.

Generally, casualties are corrected by replacing a defective part. Most of the time, the defective component is thrown away afterwards. However, certain parts such as PC cards, pumps, motors, and major valve block assemblies usually are expensive, but repairable, items. It would be a very costly and time-consuming practice if the Navy had to obtain brand new replacement parts all the time. Repairable items, such as those mentioned above, can be repaired/rebuilt cheaply if they fail. The end result is a tremendous savings in time and dollars.

For the turn-in program to work, you have a few responsibilities to fulfill. When you order a replacement part, supply personnel will check their records. They will inform you if the part is identified as a repairable turn-in item. Then, you should take the following actions:

1. Remove the defective part from the equipment. Do so carefully and try not to worsen the damage. Further (unnecessary) damage only extends the time and money needed to repair/rebuild the item.

2. Resist the temptation to cannibalize (strip) the item for spare parts.

3. Take care to protect the part from further damage. The best method here is to place the defective part in the same shipping container/box in which you receive the replacement part.

4. Return the defective part to supply personnel as soon as possible.

If the replacement part is carried on board and in stock, you're in luck. The entire turn-in process can be completed within one day. If the item is NIS or N/C, supply will place it on order. If possible, the defective part should be removed from the equipment and turned over to supply at this time. This way it can enter the repair cycle and be available for reissue that much sooner. However, there is an exception to this rule. The part may "remain in place" if its removal will further limit or reduce the equipment's operation. The defective component will be turned in to the supply department after the new part is received and installed.

IDENTIFYING AND ORDERING PUBLICATIONS

We discussed various ordnance publications earlier in the chapter. Because of normal wear and tear, you may need to renew/replace your technical publications. Occasionally, you may wish to have certain other reference sources available. Publications are treated in the same manner as repair parts; they are ordered through the supply system.

Normally, your local NAVSEA support office provides assistance in obtaining and maintaining the required publications. From time to time, they will inspect and inventory the pubs you possess. Special attention will be given to a manual's change level. If your OPs are behind in the necessary changes, NAVSEA will help obtain them.

New or replacement publications can be obtained if you consult two sources of information:

1. Index of Ordnance Publications, TO751-AD-IDX-010
2. NAVSUP PUB 2002, Navy Stock List of Publications and Forms

Index of Ordnance Publications

The Index of Ordnance Publications has replaced the former NAVSEA OP 0. The Index is published under the Ships Technical Publication System (STEPS). It is prepared and maintained by the Naval Sea Data Support Activity (NSDSA) at NSWSES.

The Index is produced in microfiche form and is updated quarterly. It lists all current OPs, ODs, TMINS pubs, and appropriate Army FMs and TMs (small arms). Also included is a listing of all changes applicable to each publication. The Index does not list historical or obsolete ordnance publications.

Figure 15-17 illustrates an Index of Ordnance Publications page format. Our example applies to the Mk 10 GMLS's technical manual SW394-AC-MMA-010/Index.

NAVSUP P-2002

NAVSUP P-2002 (P for publication) is the Navy supply system's counterpart to the STEPS Index of Ordnance Publications. NAVSUP P-2002 is prepared and issued by the Naval Publications and Forms Center (NPFC), Philadelphia, Pa. This publication is produced in microfiche form and updated quarterly. It lists all the current COG 0I publications and COG 1I forms stocked at NPFC. Additionally, it reflects such data as canceled, superseded, and replaced stock number information.

Figure 15-18 illustrates a NAVSUP P-2002 page format. Again, our example applies to the Mk 10 GMLS's SW394-AC-MMA-010/Index. Compare figures 15-17 and 15-18. The Index of Ordnance Publications shows much more "technical" data related to the pub. NAVSUP P-2002 shows stock numbers only. When ordering publications, you would be wise to consult both the Index and 2002.

Requisitions for material held at NPFC, Philadelphia, must be submitted on the standard 1250 or 1348 forms. If a complete pub is required, only order the basic/original manual. All changes and revisions will be shipped with the basic manual. If only individual changes are desired, requisition them by assigned NSN. If the publication has a TMINS number, it may be ordered without using a stock number. Complete the 1250 or 1348 normally, but substitute the 13-character TMINS number in place of the NSN.

Microfiche

We have mentioned the term "microfiche" a couple of times and it should be explained. It involves the process of transferring the information of a printed document onto microfilm. For example, a certain publication may consist of 20 volumes with over 2,000 pages. The same pub (containing the same information) can be reduced to about thirty-five 4 × 6-inch microfiche cards. The advantages are enormous—less bulk, less cost, easier republishing, and so forth.

The information in many supply catalogs has been transferred to microfilm. Your service record in Washington, D.C., is on microfilm. Many technical publications are making the transition to microfilm.

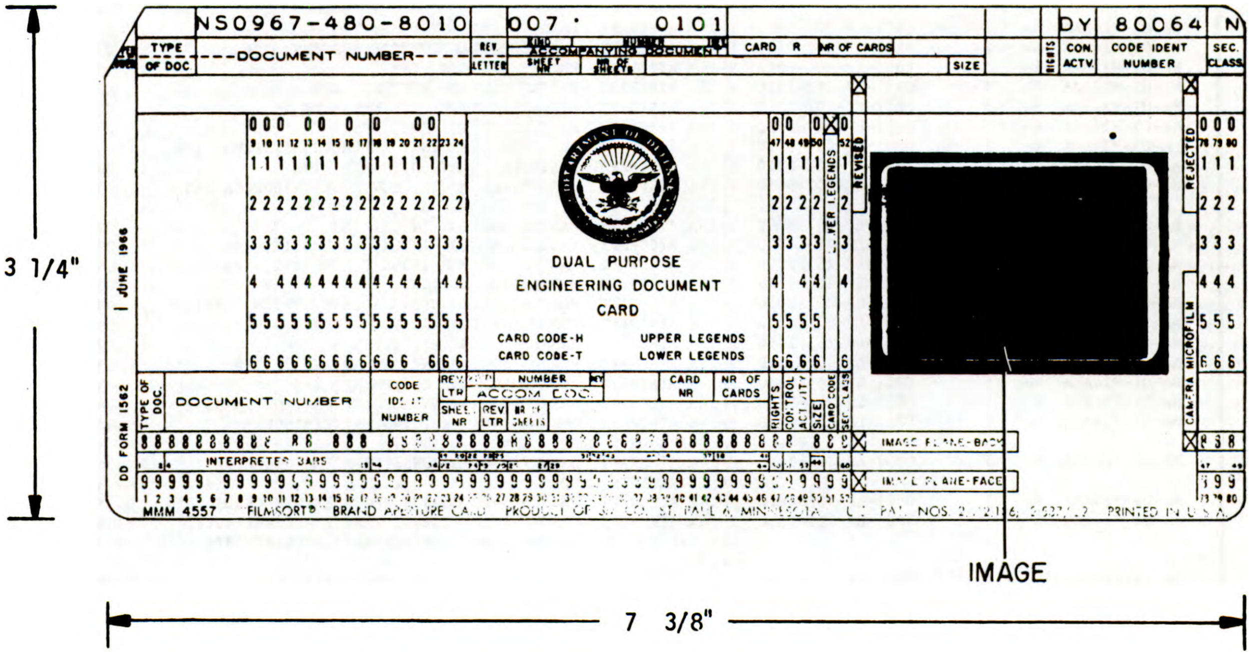
MICROFICHE MEDIA.—Three basic types of microfiche software are reel, aperture card, and microfiche card. Microfilm reels are very similar to rolls of 35-mm film. An aperture card is

```
TO751-AD-IDX-01C              O R D N A N C E                                                          05 APR 83     PAGE 8191

PUB NUMBER REV VOL CH      P U B   T I T L E                            TYPE  STAT  PUB DATE   RET    PT  USAGE  GROUP  FSCN   LVL

SW394-AC-MMA-010           GUIDED MISSILE LAUNCHING SYSTEM MK 10 MODS 0, 1, 2,   FI    09/01/79   00288      E      0     44114   0
                           5, 6, 7 AND 8; INDEX
                           COG ACTY: 63394          SEC: U  DIST: L  RTS: U  MEDIA: H  VERIF: H  EST PUB DATE:
                           FEDERAL STOCK NO: 0640-LP-000-8700  PREP ACTY: 63394       TMINS SUFFIX: /LS10 INDEX

SW394-AC-MMA-01A           CHG 1 TO SW394-AC-MMA-010                    CHG   FI    12/01/79   00288      E      0             0
                           COG ACTY: 63394          SEC: U  DIST: U  RTS: U  MEDIA: H  VERIF: H  EST PUB DATE:
                           FEDERAL STOCK NO: 0640-LP-000-8701  PREP ACTY: 44114       TMINS SUFFIX: /LS MK 10 INDEX

SW394-AC-MMA-01B           CHG 2 TO SW394-AC-MMA-010                    CHG   FI    12/01/79              E      0     44114   0
                           COG ACTY: 63394          SEC: U  DIST: U  RTS: U  MEDIA: H  VERIF: H  EST PUB DATE:
                           FEDERAL STOCK NO: 0640-LP-000-8702  PREP ACTY: 63394 (5112) TMINS SUFFIX: /LS MK 10 INDEX

SW394-AC-MMA-01C           CHG C TO SW394-AC-MMA-010                    CHG   FI    09/01/79   00288      E      0     44114   0
                           COG ACTY: 63394          SEC: U  DIST: U  RTS: U  MEDIA: H  VERIF: H  EST PUB DATE:
                           FEDERAL STOCK NO: 0640-LP-000-8703  PREP ACTY: 63394 (5112) TMINS SUFFIX: /LS MK 10 INDEX

SW394-AC-MMA-01D           CHG D TO SW394-AC-MMA-010                    CHG   FI    05/01/80   00288      E      0     44114   0
                           COG ACTY: 63394          SEC: U  DIST: U  RTS: U  MEDIA: H  VERIF: H  EST PUB DATE:
                           FEDERAL STOCK NO: 0640-LP-000-8704  PREP ACTY: 63394 (5112) TMINS SUFFIX: /LS MK 10 INDEX

SW394-AC-MMA-01E           CHG E TO SW394-AC-MMA-010                    CHG   FI    11/01/81   00288      E      0     44114   0
                           COG ACTY: 63394 (5112)   SEC: U  DIST: L  RTS: U  MEDIA:    VERIF: H  EST PUB DATE:
                           FEDERAL STOCK NO: 0640-LP-000-8705  PREP ACTY: 63394 (5112) TMINS SUFFIX: /LS10 INDEX
```

Figure 15-17.—Index of ordnance publications; example.

PUBLICATION NUMBER	STOCK NUMBER	TITLE/NOMENCLATURE	REV DATE	B/C	QR	UI PS RR M FN
SW394-AC-MMA-01A	0640-LP-000-8701	CHANGE A	12/01/79	C		6 EA
SW394-AC-MMA-01B	0640-LP-000-8702	CHANGE B	12/15/79	C		6 EA
SW394-AC-MMA-01C/LS10 INDEX	0640-LP-000-8703	CHANGE C	12/01/79	C		6 EA
SW394-AC-MMA-01D	0640-LP-000-8704	CHANGE D	05/01/80	C		6 EA
SW394-AC-MMA-01E	0640-LP-000-8705	CHANGE E	11/00/81	C		6 EA
SW394-AC-MMA-01F/LS10 INDEX	0640-LP-000-8706	CHANGE F	04/00/82	C		6 EA
SW394-AC-MMA-010/LS10 INDEX	0640-LP-000-8700	GUIDED MISSILE LAUNCHING SYSTEM MARK 10 MODS 0, 1, 2, 5, 6, 7 & 8 INDEX	09/01/79	B		6 EA

Figure 15-18.—NAVSUP P-2002; example.



83.591

Figure 15-19.—Aperture card; example.

shown in figure 15-19. It consists of one print mounted to a standard "Do Not Fold, Mutilate, or Spindle" type of computer card. Reel and aperture cards are popular methods used to display a GMLS's manufacturer's drawings/blueprints.

The third type of microfiche medium is the 4 × 6-inch microfiche card. It is a piece of negative film with transparent letters/numbers on a dark background. Refer to figure 15-20. A heading is placed at the top of the microfiche card. It is large enough to be read by the naked eye and identifies the microfiche. Heading data consists of the publication's name, assigned number, effective date, and so forth.

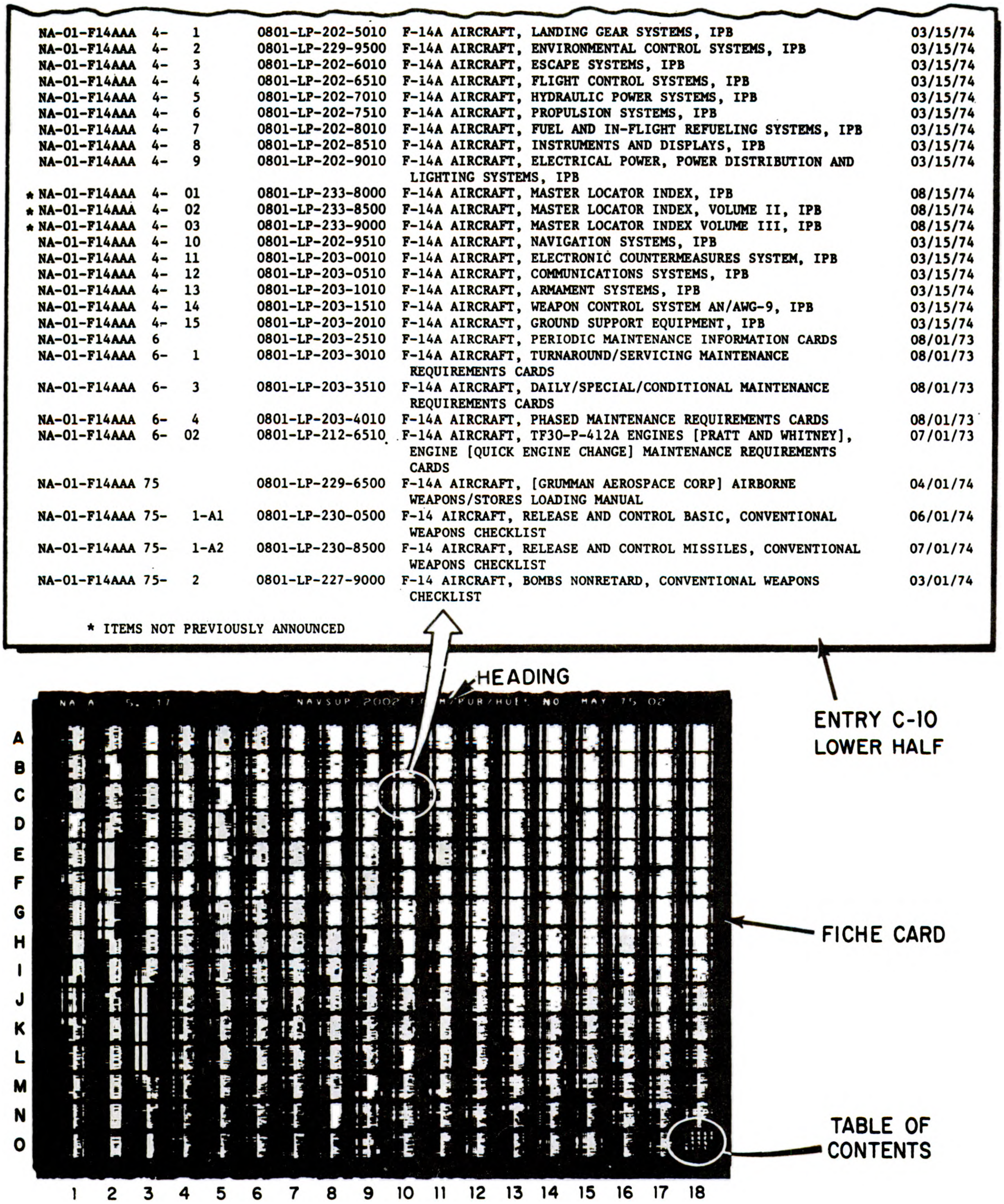
The supply system uses microfiche extensively. The Navy Management Data List (NMDL) is important to you. It provides us (you and the Storekeeper) with the necessary data to complete a 1250 or 1348 requisition form. The NMDL is arranged in NSN sequence and lists such information as units of issue, unit price, shelf life, and so on.

MICROFICHE EQUIPMENT.—Microfiche cards of a publication (e.g., the NMDL, Index of Ordnance Publications, and NAVSUP PUB 2002) usually come in multicard sets. Special binders are provided to protect and organize the individual microfiche cards. When you use microfiche, remember two golden rules:

1. Return the card to its proper and designated location.

2. Handle the cards carefully and don't leave fingerprints on the film.

Unless you are Superman, you will need a machine to enlarge the microprinting! There are two basic microfiche-reading machines in use—(1) a reader, and (2) a reader-printer. Both machines are available in different models and have

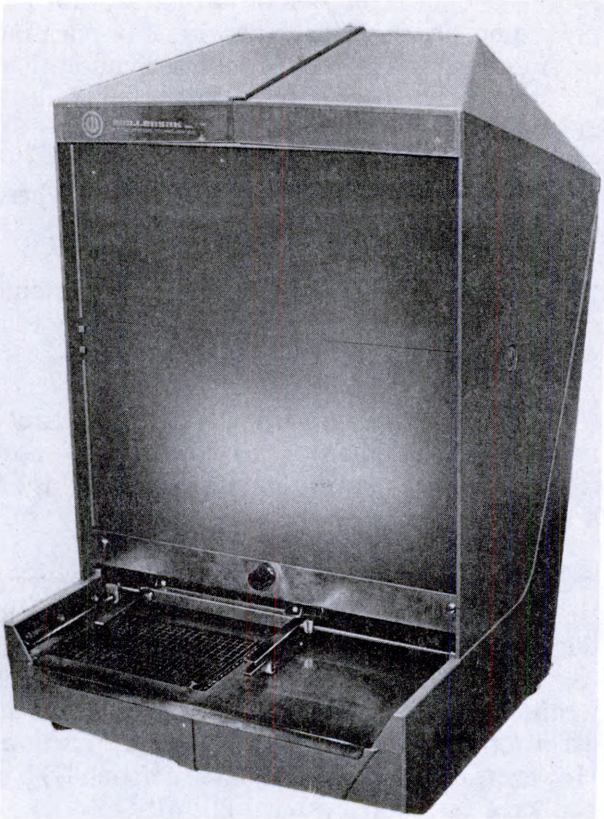


NA-01-F14AAA	4-	1	0801-LP-202-5010	F-14A AIRCRAFT, LANDING GEAR SYSTEMS, IPB	03/15/74
NA-01-F14AAA	4-	2	0801-LP-229-9500	F-14A AIRCRAFT, ENVIRONMENTAL CONTROL SYSTEMS, IPB	03/15/74
NA-01-F14AAA	4-	3	0801-LP-202-6010	F-14A AIRCRAFT, ESCAPE SYSTEMS, IPB	03/15/74
NA-01-F14AAA	4-	4	0801-LP-202-6510	F-14A AIRCRAFT, FLIGHT CONTROL SYSTEMS, IPB	03/15/74
NA-01-F14AAA	4-	5	0801-LP-202-7010	F-14A AIRCRAFT, HYDRAULIC POWER SYSTEMS, IPB	03/15/74
NA-01-F14AAA	4-	6	0801-LP-202-7510	F-14A AIRCRAFT, PROPULSION SYSTEMS, IPB	03/15/74
NA-01-F14AAA	4-	7	0801-LP-202-8010	F-14A AIRCRAFT, FUEL AND IN-FLIGHT REFUELING SYSTEMS, IPB	03/15/74
NA-01-F14AAA	4-	8	0801-LP-202-8510	F-14A AIRCRAFT, INSTRUMENTS AND DISPLAYS, IPB	03/15/74
NA-01-F14AAA	4-	9	0801-LP-202-9010	F-14A AIRCRAFT, ELECTRICAL POWER, POWER DISTRIBUTION AND LIGHTING SYSTEMS, IPB	03/15/74
* NA-01-F14AAA	4-	01	0801-LP-233-8000	F-14A AIRCRAFT, MASTER LOCATOR INDEX, IPB	08/15/74
* NA-01-F14AAA	4-	02	0801-LP-233-8500	F-14A AIRCRAFT, MASTER LOCATOR INDEX, VOLUME II, IPB	08/15/74
* NA-01-F14AAA	4-	03	0801-LP-233-9000	F-14A AIRCRAFT, MASTER LOCATOR INDEX VOLUME III, IPB	08/15/74
NA-01-F14AAA	4-	10	0801-LP-202-9510	F-14A AIRCRAFT, NAVIGATION SYSTEMS, IPB	03/15/74
NA-01-F14AAA	4-	11	0801-LP-203-0010	F-14A AIRCRAFT, ELECTRONIC COUNTERMEASURES SYSTEM, IPB	03/15/74
NA-01-F14AAA	4-	12	0801-LP-203-0510	F-14A AIRCRAFT, COMMUNICATIONS SYSTEMS, IPB	03/15/74
NA-01-F14AAA	4-	13	0801-LP-203-1010	F-14A AIRCRAFT, ARMAMENT SYSTEMS, IPB	03/15/74
NA-01-F14AAA	4-	14	0801-LP-203-1510	F-14A AIRCRAFT, WEAPON CONTROL SYSTEM AN/AWG-9, IPB	03/15/74
NA-01-F14AAA	4-	15	0801-LP-203-2010	F-14A AIRCRAFT, GROUND SUPPORT EQUIPMENT, IPB	03/15/74
NA-01-F14AAA	6		0801-LP-203-2510	F-14A AIRCRAFT, PERIODIC MAINTENANCE INFORMATION CARDS	08/01/73
NA-01-F14AAA	6-	1	0801-LP-203-3010	F-14A AIRCRAFT, TURNAROUND/SERVICING MAINTENANCE REQUIREMENTS CARDS	08/01/73
NA-01-F14AAA	6-	3	0801-LP-203-3510	F-14A AIRCRAFT, DAILY/SPECIAL/CONDITIONAL MAINTENANCE REQUIREMENTS CARDS	08/01/73
NA-01-F14AAA	6-	4	0801-LP-203-4010	F-14A AIRCRAFT, PHASED MAINTENANCE REQUIREMENTS CARDS	08/01/73
NA-01-F14AAA	6-	02	0801-LP-212-6510	F-14A AIRCRAFT, TF30-P-412A ENGINES [PRATT AND WHITNEY], ENGINE [QUICK ENGINE CHANGE] MAINTENANCE REQUIREMENTS CARDS	07/01/73
NA-01-F14AAA	75		0801-LP-229-6500	F-14A AIRCRAFT, [GRUMMAN AEROSPACE CORP] AIRBORNE WEAPONS/STORES LOADING MANUAL	04/01/74
NA-01-F14AAA	75-	1-A1	0801-LP-230-0500	F-14 AIRCRAFT, RELEASE AND CONTROL BASIC, CONVENTIONAL WEAPONS CHECKLIST	06/01/74
NA-01-F14AAA	75-	1-A2	0801-LP-230-8500	F-14 AIRCRAFT, RELEASE AND CONTROL MISSILES, CONVENTIONAL WEAPONS CHECKLIST	07/01/74
NA-01-F14AAA	75-	2	0801-LP-227-9000	F-14 AIRCRAFT, BOMBS NONRETARD, CONVENTIONAL WEAPONS CHECKLIST	03/01/74

* ITEMS NOT PREVIOUSLY ANNOUNCED

220.580

Figure 15-20.—Microfiche card; example.



211.280

Figure 15-21.—Microfiche reader.

different capabilities. A reader (figure 15-21) is used to magnify the microfiche's contents and displays the data on a screen. A reader-printer is a slightly larger machine. Besides magnifying and displaying the data, it can also reprint the information on paper.

It takes about 30 seconds to master the operation of the reader/reader-printer hardware. Two more golden rules to remember are:

1. Be gentle with these important machines.
2. Keep the magnifying lens and screen clear of fingerprints.

SECURITY

The security of the United States depends in part upon the success achieved in safeguarding classified information and material. Naturally, security is a major factor in all military operations. It is not intended to be a separate burden imposed on naval personnel. Rather, it should be an integral part of your routine duties.

Who is responsible for matters of security in the Navy? The Secretary of the Navy, the CNO, and the Director of Naval Intelligence have important roles. They are responsible for establishing and implementing the Navy's Information Security Program. Commanding officers are directly responsible for safeguarding all classified information within their commands. An important part of this responsibility involves training personnel in security practices and procedures. When we get down to the deckplate level, you share in the responsibility. Your part may seem small, but, nevertheless, is just as important.

CLASSIFICATION DESIGNATIONS

Information or material which requires protection against unauthorized disclosure is known as classified data. Depending upon its significance to national security, the data will be assigned a Top Secret, Secret, or Confidential classification designation.

The unauthorized disclosure of such classified data could be expected to cause damage to the national security. The degrees of damage are listed below:

1. Top Secret—exceptionally grave
2. Secret—serious
3. Confidential—identifiable

SECURITY EDUCATION

Everyone receives extensive training in the matters of security. Each command maintains an active security education program. The goal of the program is to impress upon all personnel the fundamental habits of security. This must be emphasized to the point that proper discretion is exercised automatically. Performing proper safeguarding techniques when dealing with classified materials should be second nature. In other words, you don't think about it, you automatically do it.

Security training begins when an individual reports to a command. An orientation briefing must be conducted as soon as possible. This makes the new individual aware of the basic requirements for the protection of classified information. The briefing also is intended to make the individual aware of the command's security procedures. Normally, the ship's security officer will hold this briefing.

Work center supervisors have certain responsibilities within the ship's security education program. They must indoctrinate new work center members as to the specific security requirements related to their job. This is especially important if job performance requires access to classified information and material. Security training at the work center level must be a continuous function.

SECURITY STANDARDS FOR SAFEGUARDING NUCLEAR WEAPONS AND WEAPON COMPONENTS

Consider the political and military importance of nuclear weapons. Consider the destructive power of a nuclear weapon. Consider the consequences of an accidental detonation or sabotage. Nuclear weapons demand special protection. Every effort must be made to prevent unauthorized access to nuclear weapons.

Definitions

The following definitions apply throughout the Navy when used in connection with nuclear weapons.

Access—Being in close physical proximity with a nuclear weapon. Access would allow the opportunity to tamper with or damage a weapon. Normally, a person would not be considered to have access if either of the following conditions are met. First, an escort is provided for the individual when the person is in close proximity. Second, a guard is provided for the weapon when the person is in close proximity.

Technical Knowledge—The knowledge, however obtained, that enables an individual to tamper with a nuclear weapon. The results of such tampering would not be detected during normal prefire operations or monitoring inspections. Such actions could cause, then or later, unauthorized prearming, arming, launching, firing, or releasing of the weapon. Tampering may also cause, then or later, the weapon to detonate or fail to detonate.

Exclusion Area—Any designated area where one or more nuclear weapons are located.

Limited Area—A designated area surrounding one or more exclusion areas (not applicable to a shipboard environment).

Buffer Zone (Shipboard)—A defined security area around a guard sentry post. The post is at an entry control point to an exclusion area.

Controlled Position—In this context, the term "position" means a person's job or assigned duties. A person in a controlled position has access to, but no technical knowledge of, a nuclear weapon. A guard who controls entry into an exclusion area fulfills a controlled position. However, in this case, the guard (personally) has neither access nor technical knowledge.

Critical Position—A person in a critical position has both access and technical knowledge. Such a person can directly or indirectly cause the launching of a nuclear weapon. Additionally, critical positions can control or use sealed authenticators, codes, computer tapes, or release procedures pertaining to the weapon.

Two-Man Rule—During any operation that may allow access, a minimum of two authorized persons must be present. Each one must be capable of detecting incorrect or unauthorized procedures. They must also be familiar with applicable safety and security requirements.

Central Station Supervisory Alarm System—A shipboard system commonly known as the FZ alarm circuit. It is a special security or intruder alarm system protecting nuclear weapons spaces. Examples include missile houses, control rooms, magazines, and so forth. Upon alarm activation, designated security force personnel respond to the scene.

Duress System—Duress means a person in a controlled or critical position or a nuclear weapon is in danger. The system is a method by which personnel can covertly communicate a duress situation to security force members. The signal may be a prearranged body movement or phase known only to command members.

Security Force—Those personnel whose duty is to protect nuclear weapons.

Security Alert Team (SAT) (Shipboard)—Two or more security force members capable of immediate response to any security irregularity. SAT members assist those security force personnel (guards) on watch at established entry points.

Backup Alert Force (BAF) (Shipboard)—Three or more security force members in addition to (1) the guards on watch and (2) the SAT. The BAF is designed to reinforce the SAT.

Reserve Force (RF) (Shipboard)—Ten or more designated and trained personnel who respond in support of the onstation guards, SAT, and BAF.

Augmentation Force (AF)—Additional military personnel (or units) trained and capable of augmenting the onstation guards, SAT, BAF, and RF.

Entry and Access Control

Only those persons authorized by the commanding officer may be admitted to an exclusion area. The number of personnel throughout a command who have this authorization is very limited. Entry to an exclusion area is restricted to properly cleared personnel. They must have a positive need for access to a weapon. They must also have a need to enter a nuclear weapons space during the course of their assigned duties.

Entry to an exclusion area is not only limited but controlled. Authorized personnel must produce positive identification before they are admitted. As a minimum, the following "systems" will be used to control exclusion area entry:

1. A controlled picture badge system
2. The use of formal entry control rosters/lists signed by the commanding officer
3. A visitor escort system
4. A duress system

Additionally, entry control procedures to exclusion areas will comply with the two-man rule. Guards on watch at entry points control and monitor admittance procedures.

One exception to the rigid entry requirements is an emergency situation. During fire, flooding, and so forth, members of the damage control party are granted immediate access to the space. However, before they are allowed to leave the scene, they must be debriefed. The space and weapons must be thoroughly inspected and checked by authorized personnel.

Locking Systems

Only high security padlocks are acceptable for the protection of nuclear weapons spaces. The locks must be mounted on high security hasps and/or locking systems. Keys to these spaces and associated alarm systems are treated as controlled items. They are classified material with a designation at least equal to the material they protect. The commanding officer appoints designated key and lock custodians (key holders). They are responsible for maintaining strict control of these devices.

Normally, there is no requirement for use of a sentry or armed guard on spaces which are locked and alarmed. However, during these periods, random checks, not to exceed 30 minutes, must be made by a roving security patrol. This verifies the integrity of the locking devices and the alarm system.

SECURITY FORCE

The ultimate security of nuclear weapons is dependent upon the command's security force. Alarms alert the presence of an intruder, and locks may only delay entry. It is the security force that must react and physically repel the potential intruder.

Organization of a ship's security force is generally tailored to a particular command. The force will be trained and equipped to provide immediate response to all alarms and emergencies. The security force on duty consists of those guards/sentries stationed at exclusion area entry points. These personnel perform two important functions. First, they control entry to an exclusion area. Second, they are the initial or first line of protection to a nuclear weapons space. Distracting devices such as radios, books, games, and the like, are not permitted at the guard/sentry posts.

Other members of the ship's security force make up the SAT, BAF, RF, and AF. A team or force must respond to an alarm within specific time limits. The members must be appropriately armed and onstation as follows:

1. SAT—5 minutes
2. BAF—10 minutes
3. RF—15 minutes
4. AF—4 hours

Generally, the SAT and BAF members respond immediately and simultaneously. Posting the RF and AF teams is usually at the discretion of the commanding (or command duty) officer. If additional assistance is warranted for the situation/emergency, these teams will be called.

Security Force Equipment

The security force will have immediate access to weapons that provide the maximum practical firepower. All guards on duty, including escort duty, will be armed. Members armed with a pistol or shotgun will have a minimum of 10 rounds each. Members armed with rifles will have a minimum of two loaded magazines/clips.

Normal procedure requires that the weapons NOT be loaded. The weapon will be held in one hand; the ammunition (clip, shell) held in the other, at the ready.

Security Force Training

Again, security force training will be tailored to individual commands. However, certain requirements and operational procedures are common to all ships. All training must be documented. This ensures that every security force member is being kept informed and up to date in applicable procedures and methods.

Personnel newly assigned to the security force will undergo a structured course of instruction. As a minimum, this includes the following subjects/actions:

1. Personnel Reliability Program (PRP)
2. General orders
3. Operation and use of communication equipment, as appropriate
4. Application of deadly force
5. Rules of engagement (to include personnel identification, apprehension, and control)
6. Appreciation for local threat
7. Overview of the local security plan
8. Logistical movements when appropriate
9. Procedures for drills and exercises
10. Overview on operation and instructions in the use of alarm systems
11. Qualification for side arms and familiarization firing of other weapons used by the security force

All indoctrination training will be certified in writing. On-the-job training follows the indoctrination course. This includes "break-in watches" with experienced watchstanders and participation in weapons movements.

Detailed guidance and follow-on training will be provided to all security force members. Orders and instructions for each security post/station must be posted and emphasized. Such regulations are drafted by the security officer and approved by the commanding officer. The orders and instructions address the following matters:

1. Information on each post to include description, hours manned, special orders applicable, and so on
2. Guidance on the use of deadly force
3. Guidance on the rules of engagement
4. Entry control procedures (normal and emergency)
5. Duress procedures

Security "Exercises"

Before we continue, an important point must be made and stressed about security. Certain events or words passed over a ship's general announcing system will be preceded by, "This is a drill." General quarters, fire, flooding, and so on are such examples. You will NEVER hear "This is a drill, security alert."

The point . . . security, especially regarding to shipboard nuclear weapons, is a constant and real part of life. Vigilance cannot be relaxed. Security and security alerts are NOT treated as "make believe" or simulated drills.

Frequent security "exercises" must be conducted to ensure the security force is proficient in its duties. SAT and BAF teams will be exercised each day in port. Underway exercises may be waived in lieu of operational considerations. However, the interval between exercises should not exceed 30 days.

Ships in foreign ports may waive security exercises if such activities would duly cause host country concern. Before entering such ports, security teams will be thoroughly exercised. Additionally, they will be briefed on the nature of any anticipated threats to security and given special instructions.

The RF and AF should be exercised at least every 30 days. Security training and exercising are constant affairs.

PERSONNEL RELIABILITY PROGRAM (PRP)

The personnel reliability program (PRP) is used by all naval commands and activities responsible for operating and maintaining nuclear weapons. It is a program with which you, as a GMM, will be deeply concerned. PRP criteria govern the selection and retention of personnel in billets—

1. having access to and/or technical knowledge of nuclear weapons.
2. identified as controlled or critical positions regarding nuclear weapons.

Personnel not certified as meeting the standards of the PRP must not perform duties in controlled or critical positions. Consequently, they may not receive formal courses of instruction necessary for and leading to a PRP assignment.

Before personnel may enter the PRP, they must be certified. This is done by the command's certifying official, who is the commanding officer. However, such authority may be delegated, in writing, to the executive, department, or division officer level.

The certifying official determines whether an individual is acceptable for a PRP assignment. Acceptance is based on the following guidelines:

1. Security investigation and security clearance
2. Medical evaluation
3. Personnel files
4. Personal interview
5. Proficiency certification

Security Investigations and Clearances

All personnel assigned to PRP positions must have appropriate security clearances. Clearances of naval personnel who are U.S. citizens or U.S. nationals are based on various investigation requirements. These include the background investigation (BI), national agency check (NAC), and entrance NAC (ENTNAC). Clearances obtained may be Top Secret, Secret, or Confidential. Interim (or temporary) clearances may be granted in certain situations.

Medical Evaluation

A medical evaluation is part of the PRP screening process. It is used to determine a candidate's physical and mental condition and qualifications under PRP standards. Screening of medical records is done by competent medical authority. These personnel are specifically trained and designated to perform this function.

Personnel Files

A detailed review of a candidate's personal file must be performed prior to PRP certification. Other official reports and locally available information may be used also. The records are screened to ascertain any behavior or conduct traits which could be relevant to PRP standards.

Personal Interview

The certifying official is required to conduct a personal interview with each PRP candidate.

The purpose of the interview is to inform the individual of the significance of—

1. the PRP assignment.
2. PRP reliability standards.
3. the need for continued reliable performance.
4. determining the individual's attitude toward the PRP.

Proficiency Certification

A proficiency certification indicates that the individual is professionally or technically skilled in the duties to be performed. To meet this requirement, the candidate may have completed a formal course of instruction (e.g., a "C" school). The candidate may also have received other supervised training and experience related to the assigned job.

PRP Performance and Obligation

All personnel assigned to PRP positions must be evaluated continually. Any adverse information that might bear on the reliability of PRP personnel must be reported to proper authority immediately. In most cases, the certifying official is considered the proper authority.

Individuals in the PRP also have certain obligations. They must report any factors or conditions which may adversely affect their performance within the PRP.

SECURITY REFERENCES

Without a doubt, security will be a major factor of your military and professional duties. We recommend you become familiar with the following two references:

1. *Information Security Program Regulation,* OPNAV Instruction 5510.1F (latest revision)
2. *Navy Nuclear Weapon Security Manual,* OPNAV Instruction 5510.83D (latest revision)

Security is a full-time, all-hands responsibility. Pay strict attention to all lectures and training sessions. Let your performance become an automatic, second-nature habit.

REFERENCES

The following reference materials were used to develop the subject matter of this chapter.

1. NAVEDTRA 10199-C, *Gunner's Mate M 3 & 2*
2. NAVEDTRA 10200-D, *Gunner's Mate M 1 & C*
3. NAVEDTRA 10185-C, *Gunner's Mate G 3 & 2*
4. NAVEDTRA 10186-D1, *Gunner's Mate G 1 & C*
5. NAVEDTRA 10224, *Fire Control Technician M 3*
6. NAVEDTRA 10207-B, *Fire Control Technician G 3 & 2*
7. NAVEDTRA 10269-J, *Storekeeper 3 & 2*
8. NAVEDTRA 10163-D, *Torpedoman's Mate 3 & 2*
9. NAVEDTRA 10056-E1, *Military Requirements for Petty Officer 3 & 2*
10. NAVEDTRA 10867-C1, *The Weapons Officer*
11. OPNAVINST 4790.4, *Ships' 3-M Manual*
12. *SECAS Program Manual,* Volume 4, Shipboard Operations

INDEX

A

- Accessories and devices, special, 13-59 to 13-71
- Accessories, demolition, 12-21 to 12-23
- Administration and security, 15-1 to 15-46
  - alterations, 15-26 to 15-28
    - ORDALTS, 15-28
    - SAIL, 15-29
    - SECAS, 15-28 to 15-29
    - SHIPALTS, 15-28
  - forms and reports, 15-21 to 15-26
    - CONAR, 15-24
    - DCAP, 15-24 to 15-26
    - Ships' 3-M Systems, the, 15-22 to 15-24
  - logs and records, 15-10 to 15-21
    - ammunition ledger, 15-13
    - guided missile service record 15-14 to 15-21
    - magazine log, 15-13
    - magazine temperature recordkeeping, 15-13 to 15-14
    - nonexpendable shipboard equipment status log, 15-10 to 15-12
    - rough equipment log, 15-10
    - small arms log, 15-13
    - weapons system smooth log, 15-12 to 15-13
  - paperwork pointers, 15-26
  - publications, 15-1 to 15-10
    - Naval Ship's Technical Manual, 15-4
    - ordnance data publications, 15-3
    - ordnance publications, 15-2 to 15-3
    - publication changes, 15-5 to 15-7
    - SMS technical bulletins, 15-8 to 15-10
    - special weapons ordnance publications, 15-8

- Administration and Security—Continued
  - publications—Continued
    - technical manuals, 15-3
    - TMINS, 15-4 to 15-5
  - references, 15-46
  - security, 15-41 to 15-46
    - classification designations, 15-41
    - personnel reliability program (PRP), 15-45 to 15-46
    - security education, 15-41 to 15-42
    - security force, 15-43 to 15-45
    - security references, 15-46
    - security standards for safeguarding nuclear weapons and weapon components, 15-42 to 15-43
  - supply, 15-29 to 15-41
    - identifying and ordering publications, 15-36 to 15-41
    - ordering a repair part, 15-32 to 15-36
- Alignment, synchro system, 11-43 to 11-47
- Alterations, 15-26
- Ammunition ledger, 15-13
- Automatic and semiautomatic firing systems, 13-6 to 13-7

B

- Basic demolition setup, a, 12-23 to 12-26
- Basic handtools, the, 10-19 to 10-31

C

- Casualties, types and causes of, 11-1 to 11-3
- Casualty analysis, 11-3 to 11-4
- Chambering, 13-5
- Changes, publication, 15-5 to 15-7
- Charge initiators, demolition, 12-17 to 12-21

Charges, demolition, 12-12 to 12-17
Classification designations, 15-41
Classification of explosives, 12-2
Classification phase, 9-16
Cleaning and preservation, 14-31
Cleaning and preservation precautions, 10-18 to 10-19
Cleaning practices, 10-44 to 10-45
Cocking, 13-6
CONAR, 15-24
Containers and handling equipment, missile, 14-4 to 14-24
Corrective maintenance, 10-2
Corrosion control, 10-15 to 10-19
Cycles of operation, 13-4 to 13-6

D

Daily system operability test, 9-22 to 9-25
DCAP, 15-24 to 15-26
Demolition, pyrotechnics, and explosives, 12-1 to 12-35
Detection, 9-1 to 9-5
Detection phase, 9-16
Dies and taps, 10-36 to 10-41
Dockside replenishment, 14-28
Documentation, troubleshooting, 11-5 to 11-20
Drawings, types of, 10-3 to 10-4
Dummy director, 11-49 to 11-50

E

Ejecting, 13-6
Electrical system maintenance, 10-42 to 10-45
Electronic warfare support measures, 9-4 to 9-5
Equipments and maintenance, magazine, 14-34 to 14-41
Error recorder, 11-50 to 11-55
Explosive ordnance safety, 12-34 to 12-35
Explosives, demolition, and pyrotechnics, 12-1 to 12-35
  demolition materials, 12-9 to 12-26
    basic demolition setup, a, 12-23 to 12-26
    demolition accessories, 12-21 to 12-23
    demolition charge initiators, 12-17 to 12-21
Explosives, demolition, and pyrotechnics—Continued
  demolition materials—Continued
    demolition charges, 12-12 to 12-17
    demolition explosives, 12-9 to 12-11
    identification of demolition materials, 12-9
    terms used with demolition operations, 12-11 to 12-12
  explosive ordnance safety, 12-34 to 12-35
  explosives defined, 12-1 to 12-9
    characteristics, 12-3 to 12-4
    classification of explosives, 12-2
    high explosives, 12-1
    low explosives, 12-1 to 12-2
    service explosives, 12-4 to 12-9
  pyrotechnics, 12-26 to 12-34
    hand-held pyrotechnic devices, 12-27 to 12-29
    pyrotechnic marking devices, 12-32 to 12-34
    pyrotechnic signals and pistols, 12-29 to 12-32
    pyrotechnics—general information, 12-26 to 12-27
  reference sources, 12-35
Extracting, 13-5

F

Fastening devices, 10-33 to 10-36
Feeding, 13-4
.50-caliber Browning machine gun, the, 13-32 to 13-48
Fire control system, 9-9 to 9-13
Firing, 13-5
Forms and reports, 15-21 to 15-26
40-mm M79 grenade launcher, the, 13-65 to 13-69
.45-caliber semiautomatic pistol (SAP), the, 13-8 to 13-15

G

General maintenance, 10-1 to 10-58
  corrosion control, 10-15 to 10-19
    cleaning, 10-17 to 10-18
    cleaning and preservation precautions, 10-18 to 10-19

General maintenance—Continued
  corrosion control—Continued
    metal corrosion, 10-15 to 10-17
    preservation, 10-18
  electrical system maintenance, 10-42 to 10-45
    cleaning practices, 10-44 to 10-45
    visual inspections, 10-43 to 10-44
  general maintenance—conclusion, 10-58
  lubrication, 10-5 to 10-15
    greases, 10-10 to 10-11
    lubricating devices, 10-11 to 10-13
    lubrication instructions, 10-5 to 10-7
    power-transmission (hydraulic) fluids, 10-13 to 10-15
    purpose of lubricants, 10-5
    qualities of lubricants, 10-7 to 10-9
    types and properties of lubricants, 10-9 to 10-10
  maintenance defined, 10-1 to 10-3
    corrective maintenance, 10-2
    maintenance levels, 10-2 to 10-3
    preventive maintenance, 10-1
  ordnance drawings, 10-3 to 10-5
    how to use drawings, 10-4 to 10-5
    types of drawings, 10-3 to 10-4
  tools, 10-19 to 10-42
    basic handtools, the, 10-19 to 10-31
    fastening devices, 10-33 to 10-36
    personal safety equipment, 10-41 to 10-42
    power tools, 10-31 to 10-33
    taps and dies, 10-36 to 10-41
    tools—conclusion, 10-42
  wiring techniques, 10-45 to 10-58
    insulating wire, 10-52
    lacing and tieing, 10-56 to 10-58
    soldering, 10-45 to 10-50
    splice connections, 10-56
    stripping wire, 10-50 to 10-52
    terminal connections, 10-52 to 10-55
GMLS troubleshooting documents, 11-10 to 11-13
Greases, 10-10 to 10-11
Grenade launcher, the 40-mm M79, 13-65 to 13-69
Guidance phase, 9-16 to 9-18
Guided missile service record, 15-14 to 15-21
Guided missile weapons system, 9-1 to 9-32
  detection, 9-1 to 9-5
    electronic warfare support measures, 9-4 to 9-5
    naval tactical data system, 9-5
    search radars, 9-2 to 9-4
  reference sources, 9-32
  training missiles, 9-25 to 9-32
    general purposes, 9-26
    Tartar GMTR, 9-29 to 9-31
    Terrier TSAM, 9-26 to 9-29
    training missile maintenance, 9-31 to 9-32
  WCS operational phases, 9-16 to 9-19
    missile guidance phase, 9-16 to 9-18
    missile launching phase, 9-16
    missile selection phase, 9-16
    problem sequence, 9-18 to 9-19
    target classification phase, 9-16
    target detection phase, 9-16
    target location phase, 9-16
  weapon system maintenance, 9-19 to 9-25
    daily system operability test, 9-22 to 9-25
    system testing, 9-19 to 9-22
  weapons control system, 9-5 to 9-16
    fire control system, 9-9 to 9-13
    missile control, 9-13 to 9-16
    weapons direction system, 9-6 to 9-9

H

Hand grenades, 13-69 to 13-71
Hand-held pyrotechnic devices, 12-27 to 12-29
Handguns, 13-8 to 13-21
Handling equipment and containers, missile, 14-4 to 14-24
Handling, missiles aboard ship, 14-29 to 14-30
Handtools, the basic, 10-19 to 10-31
High explosives, 12-1
How to use drawings, 10-4 to 10-5
Hydraulic (power-transmission) fluids, 10-13 to 10-15

I

Identification of demolition materials, 12-9 to 12-11
Identifying and ordering publications, 15-36 to 15-41

Initiators, demolition charge, 12-17 to 12-21
Insulating wire, 10-52
Issue and stowage of small arms, 13-73

L

Lacing and tieing, 10-56 to 10-58
Launching phase, 9-16
Lighter replenishment, 14-28 to 14-29
Line-throwing rifle adapter kit, the Mk-87 Mod 1, 13-60 to 13-65
Locking, 13-5
Logical troubleshooting, 11-5
Logs and records, 15-10 to 15-21
Low explosives, 12-1 to 12-2
Lubrication, 10-5 to 10-15

M

M14 rifle, 13-21 to 13-28
Machine guns, 13-32 to 13-59
Magazine log, 15-13
Magazine temperature recordkeeping, 15-13 to 15-14
Magazines and missile handling, 14-1 to 14-41
Maintaining a synchro system, 11-47
Maintenance and equipment magazine, 14-34 to 14-41
Maintenance defined, 10-1 to 10-3
Maintenance levels, 10-2 to 10-3
Maintenance, small arms and machine guns, 13-7 to 13-8
Maintenance, training missile, 9-31 to 9-32
Maintenance, weapon system, 9-19 to 9-25
Marking devices, pyrotechnic, 12-32 to 12-34
Metal corrosion, 10-15 to 10-17
Meters, 11-23 to 11-26
Missile control, 9-13 to 9-16
Missile handling and magazines, 14-1 to 14-41
    magazines, 14-32 to 14-41
        magazine maintenance and equipments, 14-34 to 14-41
        types of magazines, 14-32 to 14-34
    missile handling, 14-1 to 14-24
        containers and handling equipment, 14-4 to 14-24
        weapons station processing, 14-1 to 14-4
    missiles aboard ship, 14-29 to 14-32
        cleaning and preservation, 14-31
        general tasks, 14-31 to 14-32
Missile handling and magazines—Continued
    missiles aboard ship—Continued
        handling, 14-29 to 14-30
        inspections, 14-30 to 14-31
        stowage, 14-30
    references, 14-41
    replenishment methods, 14-24 to 14-29
        dockside replenishment, 14-28
        lighter replenishment, 14-28 to 14-29
        UNREP-CONREP, 14-26
        VERTREP, 14-26 to 14-27
Missiles aboard ship, 14-29 to 14-32
Mk-87 Mod 1 line-throwing rifle adapter kit, the, 13-60 to 13-65

N

Naval Ships' Technical Manual, 15-4
Naval tactical data system, 9-5
Nonexpendable shipboard equipment status log, 15-10 to 15-12

O

ORDALTS, 15-28
Ordering a repair part, 15-32 to 15-36
Ordnance data publications, 15-3
Ordnance drawings, 10-3 to 10-5
Ordnance publications, 15-2 to 15-3
Ordnance safety, explosive, 12-34 to 12-35

P

Paperwork pointers, 15-26
Personal safety equipment, 10-41 to 10-42
Personnel reliability program (PRP), 15-45 to 15-46
Pistols and signals, pyrotechnic, 12-32 to 12-34
Power drive performance testing, 11-48 to 11-55
Power tools, 10-31 to 10-33
Power-transmission (hydraulic) fluids, 10-13 to 10-15
Precautions for small arms, special, 13-72 to 13-73
Preservation, 10-18
Preservation and cleaning, 14-31

Preventive maintenance, 10-1
Printed and transistorized circuits, 11-39 to 11-43
Problem sequence, 9-18 to 9-19
Publication changes, 15-5 to 15-7
Publications, 15-1 to 15-10
Purpose of lubricants, 10-5
Pyrotechnics, explosives, and demolition, 12-1 to 12-35

Q

Qualities of lubricants, 10-7 to 10-9

R

Radars, search, 9-2 to 9-4
Records and logs, 15-10 to 15-21
Reference diagrams, 11-13 to 11-20
Remington M870 shotgun, the, 13-28 to 13-32
Replenishment methods, 14-24 to 14-29
Reports and forms, 15-21 to 15-26
Rough equipment log, 15-10

S

Safety equipment, personal, 10-41 to 10-42
SAIL, 15-29
7.62-mm M60 machine gun, the, 13-48 to 13-59
Search radars, 9-2 to 9-4
SECAS, 15-28 to 15-29
Security, 15-41 to 15-46
Security education, 15-41 to 15-42
Security force, 15-43 to 15-45
Security references, 15-46
Security standards for safeguarding nuclear weapons and weapon components, 15-42 to 15-43
Selection phase, 9-16
Service explosives, 12-4 to 12-9
SHIPALTS, 15-28
Ships' 3-M Systems, the, 15-22 to 15-24
Shoulder weapons, 13-21 to 13-32
Signals and pistols, pyrotechnic, 12-29 to 12-32
Small arms and machine guns, 13-1 to 13-73
    automatic and semiautomatic firing systems, 13-6 to 13-7
    cycles of operation, 13-4 to 13-6
        chambering (step 2), 13-5
        cocking (step 8), 13-6
        ejecting (step 7), 13-6
        extracting (step 6), 13-5
        feeding (step 1), 13-4
        firing (step 4), 13-5
        locking (step 3), 13-5
        unlocking (step 5), 13-5
    handguns, 13-8 to 13-21
        .45-caliber semiautomatic pistol (SAP), the, 13-8 to 13-15
        .38-cal Ruger service-six revolver, the, 13-17 to 13-21
        .38-cal Smith and Wesson (S&W) revolver, the, 13-15 to 13-17
    machine guns, 13-32 to 13-59
        .50-caliber Browing machine gun, the, 13-32 to 13-48
        7.62-mm M60 machine gun, the, 13-48 to 13-59
    maintenance, 13-7 to 13-8
    principles of operation, 13-4
    reference sources, 13-73
    shoulder weapons, 13-21 to 13-32
        M14 rifle, 13-21 to 13-28
        Remington M870 shotgun, the 13-28 to 13-32
    special accessories and devices, 13-59 to 13-71
        40-mm M79 grenade launcher, the, 13-65 to 13-69
        hand grenades, 13-69 to 13-71
        Mk-87 Mod 1 line-throwing rifle adapter kit, the, 13-60 to 13-65
    special precautions for small arms, 13-72 to 13-73
    stowage and issue of small arms, 13-73
    terminology, 13-1 to 13-4
Small arms log, 15-13
SMS technical bulletins, 15-8 to 15-10
Soldering, 10-45 to 10-50
Special precautions for small arms, 13-72 to 13-73
Special weapons ordnance publications, 15-8
Splice connections, 10-56
Stowage and issue of small arms, 13-73
Stowage, missiles aboard ship, 14-30

Stripping wire, 10-50 to 10-52
Supply, 15-29 to 15-41
Synchro systems, 11-43 to 11-48

T

Taps and dies, 10-36 to 10-41
Target location phase, 9-16
Tartar GMTR, 9-29 to 9-31
Technical manuals, 15-3
Techniques for meter use, 11-27 to 11-34
Terminal connections, 10-52 to 10-55
Terminology, 13-1 to 13-4
Terms used with demolition operations, 12-11 to 12-12
Terrier TSAM, 9-26 to 9-29
Test equipment, 11-20 to 11-39
Testing, system, 9-19 to 9-22
.38-cal Ruger service-six revolver, the, 13-17 to 13-21
.38-cal Smith and Wesson (S&W) revolver, the, 13-15 to 13-17
Tieing and lacing, 10-56 to 10-58
TMINS, 15-4 to 15-5
Tools, 10-19 to 10-42
Training missiles, 9-25 to 9-32
Transistorized and printed circuits, 11-39 to 11-43
Trouble isolation, 11-4 to 11-5
Troubleshooting and testing, 11-1 to 11-56
  power drive performance testing, 11-48 to 11-55
    dummy director, 11-49 to 11-50
    error recorder, 11-50 to 11-55
  references, 11-55 to 11-56
  synchro systems, 11-43 to 11-48
    maintaining a synchro system, 11-47
    synchro system alignment, 11-43 to 11-47
    troubleshooting synchro systems, 11-47 to 11-48
  test equipment, 11-20 to 11-39
    general information, 11-21 to 11-23
    meters, 11-23 to 11-26
Troubleshooting and testing—Continued
  test equipment—Continued
    other test equipment, 11-34 to 11-39
    techniques for meter use, 11-27 to 11-34
  transistorized and printed circuits, 11-39 to 11-43
    printed circuits, 11-41 to 11-43
    troubleshooting transistor circuits, 11-39 to 11-41
  troubleshooting, 11-1 to 11-5
    casualty analysis, 11-3 to 11-4
    logical troubleshooting, 11-5
    trouble isolation, 11-4 to 11-5
    types and causes of casualties, 11-1 to 11-3
  troubleshooting documentation, 11-5 to 11-20
    GMLS troubleshooting documents, 11-10 to 11-13
    reference diagrams, 11-13 to 11-20
    weapon system troubleshooting documents, 11-5 to 11-10
Types of magazines, 14-32 to 14-34

U

Unlocking, 13-5
UNREP-CONREP, 14-26

V

VERTREP, 14-26 to 14-27
Visual inspections, 10-43 to 10-44

W

WCS operational phases, 9-16 to 9-19
Weapon system troubleshooting documents, 11-5 to 11-10
Weapons control system, 9-5 to 9-16
Weapons direction system, 9-6 to 9-9
Weapons station processing, 14-1 to 14-4
Weapons system smooth log, 15-12 to 15-13
Wiring techniques, 10-45 to 10-48

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NONRESIDENT CAREER COURSE

GUNNER'S MATE M 3 & 2, VOLUME 2

NAVEDTRA 10189

Prepared by the Naval Education and Training Program Development
Center, Pensacola, Florida

Your NRCC contains a set of assignments and perforated answer sheets. The Rate Training Manual, Gunner's Mate Missiles 3 & 2, Volume 2 NAVEDTRA 10189, is your textbook for the NRCC. If an errata sheet comes with the NRCC, make all indicated changes or corrections. Do not change or correct the textbook or assignments in any other way.

HOW TO COMPLETE THIS COURSE SUCCESSFULLY

Study the textbook pages given at the beginning of each assignment before trying to answer the items. Pay attention to tables and illustrations as they contain a lot of information. Making your own drawings can help you understand the subject matter. Also, read the learning objectives that precede the sets of items. The learning objectives and items are based on the subject matter or study material in the textbook. The objectives tell you what you should be able to do by studying assigned textual material and answering the items.

At this point you should be ready to answer the items in the assignment. Read each item carefully. Select the BEST ANSWER for each item, consulting your textbook when necessary. Be sure to select the BEST ANSWER from the subject matter in the textbook. You may discuss difficult points in the course with others. However, the answer you select must be your own. Remove a perforated answer sheet from the back of this text, write in the proper assignment number, and enter your answer for each item.

Your NRCC will be administered by your command or, in the case of small commands, by the Naval Education and Training Program Development Center. No matter who administers your course you can complete it successfully by earning a 3.2 for each assignment. The unit breakdown of the course, if any, is shown later under Naval Reserve Retirement Credit.

WHEN YOUR COURSE IS ADMINISTERED BY LOCAL COMMAND

As soon as you have finished an assignment, submit the completed answer sheet to the officer designated to grade it. The graded answer sheet will not be returned to you.

If you are completing this NRCC to become eligible to take the fleetwide advancement examination, follow a schedule that will enable you to complete all assignments in time. Your schedule should call for the completion of at least one assignment per month.

Although you complete the course successfully, the Naval Education and Training Program Development Center will not issue you a letter of satisfactory completion. Your command will make an entry in your service record, giving you credit for your work.

WHEN YOUR COURSE IS ADMINISTERED BY THE NAVAL EDUCATION AND TRAINING PROGRAM DEVELOPMENT CENTER

After finishing an assignment, go on to the next. Retain each completed answer sheet until you finish all the assignments in a unit (or in the course if it is not divided into units). Using the envelopes provided, mail your completed answer sheets to the Naval Education and Training Program Development Center where they will be graded and the score recorded. Make sure all blanks at the top of each answer sheet are filled in. Unless you furnish all the information required, it will be impossible to give you credit for your work. The graded answer sheets will not be returned.

The Naval Education and Training Program Development Center will issue a letter of satisfactory completion to certify successful completion of the course (or a creditable unit of the course). To receive a course-completion letter, follow the directions given on the course-completion form in the back of this NRCC.

You may keep the textbook and assignments for this course. Return them only in the event you disenroll from the course or otherwise fail to complete the course. Directions for returning the textbook and assignments are given on the book-return form in the back of this NRCC.

PREPARING FOR YOUR ADVANCEMENT EXAMINATION

Your examination for advancement is based on the Occupational Standards for your rating as found in the MANUAL OF NAVY ENLISTED MANPOWER AND PERSONNEL CLASSIFICATIONS AND OCCUPATIONAL STANDARDS (NAVPERS 18068). These Occupational Standards define the minimum tasks required of your rating. The sources of questions in your advancement examination are listed in the BIBLIOGRAPHY FOR ADVANCEMENT STUDY (NAVEDTRA 10052). For your convenience, the Occupational Standards and the sources of questions for your rating are combined in a single pamphlet for the series of examinations for each year. These OCCUPATIONAL STANDARDS AND BIBLIOGRAPHY SHEETS (called Bib Sheets), are available from your ESO. Since your textbook and NRCC are among the sources listed in the bibliography, be sure to study both as you take the course. The qualifications for your rating may have changed since your course and textbook were printed, so refer to the latest edition of the Bib Sheets.

NAVAL RESERVE RETIREMENT CREDIT

This course is evaluated at 12 Naval Reserve retirement points, which will be credited upon satisfactory completion of the course. These points are creditable to personnel eligible to receive them under current directives governing the retirement of Naval Reserve personnel.

COURSE OBJECTIVE

While completing this nonresident career course the student will demonstrate knowledge of the course material by correctly answering items on the following: U.S. Navy guided missile weapons systems; characteristics, classification, and types of explosives and pyrotechnics; types of smallarms and machineguns, their function and component identification; missile handling; magazines and their protective systems; maintenance and testing of guided missile weapons systems; administrative duties of a GMM; logs, records, and reports.

While working on this correspondence course, you may refer freely to the text. You may seek advice and instruction from others on problems arising in the course, but the solutions submitted must be the result of your own work and decisions. You are prohibited from referring to or copying the solutions of others, or giving completed solutions to anyone else taking the same course.

Naval courses may include a variety of questions -- multiple-choice, true-false, matching, etc. The questions are not grouped by type; regardless of type, they are presented in the same general sequence as the textbook material upon which they are based. This presentation is designed to preserve continuity of thought, permitting step-by-step development of ideas. Some courses use many types of questions, others only a few. The student can readily identify the type of each question (and the action required) through inspection of the samples given below.

MULTIPLE-CHOICE QUESTIONS

Each question contains several alternatives, one of which provides the best answer to the question. Select the best alternative, and blacken the appropriate box on the answer sheet.

SAMPLE

s-1. The first person to be appointed Secretary of Defense under the National Security Act of 1947 was
1. George Marshall
2. James Forrestal
3. Chester Nimitz
4. William Halsey

Indicate in this way on the answer sheet:

	1 T	2 F	3	4	
s-1	☐	■	☐	☐	___

TRUE-FALSE QUESTIONS

Mark each statement true or false as indicated below. If any part of the statement is false the statement is to be considered false. Make the decision, and blacken the appropriate box on the answer sheet.

SAMPLE

s-2. Any naval officer is authorized to correspond officially with any systems command of the Department of the Navy without his commanding officer's endorsement.

Indicate in this way on the answer sheet:

	1 T	2 F	3	4	
s-2	☐	■	☐	☐	___

MATCHING QUESTIONS

Each set of questions consists of two columns, each listing words, phrases or sentences. The task is to select the item in column B which is the best match for the item in column A that is being considered. Items in column B may be used once, more than once, or not at all. Specific instructions are given with each set of questions. Select the numbers identifying the answers and blacken the appropriate boxes on the answer sheet.

SAMPLE

In questions s-3 through s-6, match the name of the shipboard officer in column A by selecting from column B the name of the department in which the officer functions.

A	B
s-3. Damage Control Assistant	1. Operations Department
s-4. CIC Officer	2. Engineering Department
s-5. Disbursing Officer	3. Supply Department
s-6. Communications Officer	

Indicate in this way on the answer sheet:

	1 T	2 F	3	4	
s-3	☐	■	☐	☐	___
s-4	■	☐	☐	☐	___
s-5	☐	☐	■	☐	___
s-6	■	☐	☐	☐	___

Assignment 1

Guided Missile Weapons Systems; General Maintenance

Textbook, NAVEDTRA 10189: Pages 9-1 through 10-5

Learning Objective: Identify the type of equipment used to detect a contact.

1-1. What type of air contact is detected by a two-coordinate radar?

1. Short-range
2. Long-range
3. Low-altitude
4. High-altitude

1-2. Which of the following sets is NOT a three-coordinate air search radar?

1. AN/SPS-39
2. AN/SPS-48
3. AN/SPS-49
4. AN/SPS-52

1-3. Which of the following sets is a short-range, two-coordinate surface search radar?

1. AN/SPS-29
2. AN/SPS-48
3. AN-SPS-52
4. AN/SPS-55

When answering questions 1-4 through 1-6, select from column B the system that fits the description in column A. Response may be used once, more than once, or not at all.

	A. Descriptions	B. Systems
1-4.	It provides comprehensive tactical data about all types of targets	1. ESM 2. NTDS
1-5.	It is capable of gaining tactical and strategic intelligence on all types of electronic activities.	
1-6.	It correlates all data and generates a clear presentation of the overall tactical situation.	

Learning Objective: Recognize the function and operating principles of the different units that make up a weapons control system.

1-7. Which of the following functions is NOT performed by the weapons control equipment?

1. Positioning the missile on the launcher
2. Positioning the missile launcher
3. Computing predicted line of fire
4. Controlling missile flight path to ensure target intercept

1-8. A weapons direction system contains how many different equipment groups?

1. One
2. Two
3. Three
4. Four

1-9. What is the primary link between the detecting units and the FCS?

1. WCS
2. DAC
3. WAC
4. WDE

When answering questions 1-10 through 1-14, select from column B the unit that fits the description in column A. Responses may be used once, more than once, or not at all.

	A. Descriptions	B. Units
1-10.	Produces a PPI and target height display	1. DAC 2. TSTC
1-11.	Performs the final evaluation of a target	3. WAC
1-12.	Determines the order of target engagement according to relative threat	
1-13.	Designates target coordinates to a GMFCS or GFCS	
1-14.	Has the firing key mounted on it	

1-15. An optical-sighting, manually controlled unit is called a

1. WAC
2. DAC
3. TSTC
4. TDT

1-16. A fire control system consists of how many major equipment groups?

1. One
2. Two
3. Three
4. Four

1-17. What type of power drive is used to position the director and antenna?

1. Electric
2. Mechanical
3. Electrohydraulic
4. Electromechanical

1-18. Which of the following factors is NOT continuously transmitted to the computer?

1. Range
2. Speed
3. Bearing
4. Elevation

When answering questions 1-19 through 1-22, select from column B the mode that fits the description in column A. Responses may be used once, more than once, or not at all.

	A. Descriptions	B. Modes
1-19.	Computer generates control and data signals to position or hold the director at 0° or 180°	1. Designate 2. Track 3. Air ready
1-20.	Radar transmits a locked-on signal to the computer	
1-21.	Director slews toward the target position	
1-22.	It causes the radar to sweep a search pattern	

1-23. When does the WAC operator assign the launcher?

1. As the target approaches the predicted intercept point
2. When the target passes the predicted intercept point
3. When the target is within the outer envelope

1-24. When are the preflight orders applied to the missile?

1. As soon as the missile is loaded on the rail
2. At launcher assignment
3. When the ITL signal is applied
4. Before the missile is removed from the magazine

When answering questions 1-25 through 1-29, select from column B the missile order that fits the description in column A. Responses may be used once, more than once, or not at all.

A. Descriptions

1-25. It causes the signal antenna to turn toward a predicted point in space

1-26. It compensates for any change in target and missile trajectories

1-27. Its signal is proportional to what the missile-to-target closing rate should be

1-28. It causes the missiles vertical axis to return to its true attitude after the missile leaves the launcher

1-29. It reduces the steering gain of the missile during the early part of flight

B. Missile Orders

1. VNR
2. Missile roll
3. Seeker
4. Doppler predict

Learning Objective: Identify the operational phases of a typical weapon central system (WCS).

1-30. What is the first phase in a WCS operation?

1. Target classification
2. Target location
3. Target detection
4. Missile selection

1-31. In what phase does a WCS designate a GMFCS?

1. Target classification
2. Target location
3. Evaluation
4. Detection

1-32. What is the last phase in a WCS operation?

1. Missile launch
2. Missile guidance
3. Target detection
4. Target acquisition

1-33. When does the missile transmit a Missile Ready indication?

1. After all the missile firing circuits are completed
2. At booster ignition
3. After the ignition of the missile booster squibs takes place
4. As the missile leaves the launcher

Learning Objective: Identify the purpose and procedure used with weapon system maintenance

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1-34. What are the system maintenance tests used for?

1. To provide separate equipment level checks
2. To evaluate the weapons system's ability to perform effectively
3. To troubleshoot at equipment level
4. To evaluate the individual equipment's ability to perform efficiently

1-35. When there are 12 different weekly tests, which one(s) will be completed on Tuesday?

1. W-1 only
2. W-2 only
3. W-1 and W-7
4. W-2 and W-8

1-36. What system test is designed to exercise most of the functional circuits related to the primary mode of system operation?

1. DSOT
2. MSOT
3. ASMD
4. ASW

1-37. When an SMT is performed, the equipment is checked in how many areas?

1. One
2. Two
3. Three
4. Four

1-38. Of the following procedures, which one is performed on an as-needed basis only?

1. Operational
2. Functional
3. Alignment
4. DSOT

1-39. When performing a DSOT, where would you find a fault isolation directory?

1. In the equipment OP
2. In the system OP
3. In an IPB
4. In the MRC

1-40. Which of the following modes of operation is/are normally checked during a DSOT?

1. AAW
2. ASW
3. SUW
4. All of the above

When answering questions 1-41 through 1-45, select from column B the step that fits the description in column A. Responses may be used once, more than once, or not at all.

A. Descriptions	B. Steps
1-41. The accuracy of the designated position is checked at the radar set console	1. Test missile readouts
1-42. The firing circuit is closed	2. Acquisition and static tract
1-43. Fire control radar receives a simulated target return signal	3. Dynamic evaluation
1-44. Visual observations by means of built-in lamps and dials are made at the simulator	4. GMFCS assignment
1-45. Target parameters are selected to simulate an incoming enemy aircraft	

Learning Objective: Identify the tests and functions of training missiles.

1-46. Which of the following GMLS does NOT use the GMTR?

1. Mk 10
2. Mk 11
3. Mk 13
4. Mk 26

1-47. Why does a combatant ship carry a GMTR/TSAM?

1. For testing
2. For training
3. Both 1 and 2 above are correct

1-48. Which of the following missiles can NOT be simulated by the Mk 74 simulator?

1. BT
2. HT/HTR
3. SM-1 (ER)
4. SM-2 (ER)

1-49. The Mk 60 Mod 4 GMTR consists of how many major subassemblies?

1. One
2. Two
3. Five
4. Six

When answering questions 1-50 through 1-52, select from column B the item number that fits the description in column A. Responses may be used once, more than once, or not at all.

A. Descriptions	B. Item Numbers
1-50. Roll correction LED display	1. 1
	2. 21
1-51. Selects the correct circuits for simulation of the desired missile type	3. 22
	4. 23
1-52. Missile code or channel number LED display	

Learning Objective: Identify the purpose, terms, and definitions of maintenance.

1-53. Specific information for a particular piece of equipment can be found where?

1. The equipment MRC
2. The system MRC
3. The equipment and system OPs
4. Each of the above

1-54. What is the purpose of preventive maintenance?

1. To keep malfunctioning at a minimum
2. To repair or replace worn parts
3. To eliminate maintenance during operating periods
4. To remove unserviceable equipment

1-55. Which of the following actions comes under the heading of corrective maintenance?

1. Inspecting the amplifier for visual signs of trouble
2. Adjustment of the amplifier after replacement of a servovalue
3. Removing dust from the brushes of a generator
4. Greasing the blast door span track

1-56. Depot level maintenance refers to the maintenance that is performed by

1. a ship's force on its own equipment
2. highly trained personnel aboard tenders
3. a maintenance crew who performs major overhauls on equipment ashore
4. a repair ship on another ship's equipment

Learning Objective: Point out the types of ordnance drawings and their use.

1-57. Which drawing should you consult if you are setting up a piece of electrical equipment and you want to know how much space the equipment requires?

1. Schematic
2. Assembly
3. Installation
4. General arrangement

1-58. Which of the following drawings should you use if you have to turn out replacement parts in your shop?

1. General arrangement
2. Detail
3. Installation
4. Tool

1-59. Which diagram should be used to find how to connect a radarscope into a system?

1. Isometric wiring
2. Schematic wiring
3. Internal wiring
4. External wiring

1-60. The primary purpose of a schematic drawing is to

1. enable you to make up a finished assembly from the prescribed parts and materials
2. help you understand the functioning of the equipment
3. show you how to wire a piece of equipment
4. show the lubrication fittings and points of a piece of equipment

1-61. The location and identification of the electrical components in a guided missile launching system is shown by means of a/an

1. installation diagram
2. schematic diagram
3. internal wiring diagram
4. external wiring diagram

1-62. Which of the following maintenance aids shows the special tools necessary for servicing a particular component?

1. A general arrangement drawing
2. An installation drawing
3. A schematic diagram
4. A list of drawings

1-63. Which of the following numbers identifies an ordnance drawing of a piece that has been altered twice?

1. 194560-2
2. 194560-2-2
3. 194560-2B
4. 2-194560

Assignment 2

General Maintenance (continued)

Textbook, NAVEDTRA 10189: Pages 10-5 through 10-45

Learning Objective: Point out the characteristics, purpose, and use of lubricants, and lubricating devices.

2-1. A lubricant is used to provide protection against which of the following factors?

1. Corrosion
2. Friction
3. Heat
4. All of the above

2-2. Lubrication instructions for ordnance equipment will be found where?

1. Maintenance requirement cards
2. Lubrication charts
3. Ordnance publications
4. All of the above

2-3. Which of the following maintenance functions is NOT shown on a lubrication chart?

1. Draining
2. Filling
3. Renovating
4. Cleaning

When answering questions 2-4 through 2-6, select from column B the quality that fits the description in column A.

	A. Descriptions	B. Qualities
2-4.	The property of a lubricant which provides the ability to withstand high temperatures or other deteriorating influences	1. Chemical stability 2. Viscosity index 3. Flash point
2-5.	The measurement of the variation of the resistance to flow of a lubricant with variation in temperature	4. Dropping point
2-6.	The temperature at which a lubricant gives off flammable vapors	

2-7. The viscosity index of a lubricant can be improved by

1. heating the lubricant
2. cooling the lubricant
3. adding inhibitors to the lubricant
4. putting chemical additives into the lubricant

2-8. Which of the following factors is NOT an important property of lubricating oils?

1. Pour point
2. Viscosity
3. Drip point
4. Viscosity index

2-9. What information is given by the last three numbers in military oil symbol 2070?

1. Viscosity index
2. Number of additives
3. Army specification
4. Class of oil

2-10. Why is graphite grease different from other greases?

1. Because it contains abrasives only
2. Because it contains soap only
3. Because it contains abrasives and soap
4. Because it contains soap and oil

2-11. Most greases are a mixture of lubricating fluids and

1. lime soap
2. graphite
3. sodium soap
4. low-viscosity oils

2-12. The lubrication fitting to be used when there is not enough room to install a protruding fitting is the

1. buttonhead type
2. pin-head type
3. flush type
4. straight hydraulic type

2-13. Why are plastic protective caps placed on hydraulic fittings?

1. To prevent entrance of dirt or water in the fitting
2. To protect the fitting during ice removal and painting
3. To prevent the greases from hardening in the fitting
4. All of the above are correct

2-14. The ingredient used as the base for a power transmission fluid is composed of

1. petroleum
2. a synthetic liquid
3. water

2-15. When the hydraulic system is inactive, which of the following contaminants will be the most harmful?

1. Dirt
2. Water
3. Metal products
4. Insoluble products

2-16. Where should you find the instructions for draining and refilling a hydraulic system?

1. MRC
2. OP
3. Both 1 and 2 above

2-17. Which of the following components will automatically vent trapped air in a hydraulic system?

1. Air-vent port
2. Breather tubes
3. Starting valve
4. Air-vent plug

Learning Objective: Identify the characteristics and procedures for corrosion control.

2-18. Corrosion in its most familiar form is an electrochemical reaction between metal and

1. water
2. dirt
3. grease
4. debris that is capable of acting as an electrolyte

When answering questions 2-19 through 2-23, select from column B the metal that fits the corrosion product characteristics in column A. Responses may be used once, more than once, or not at all.

	A. Corrosion Product Characteristics	B. Metals
2-19.	Has a white to gray powdery deposit	1. Aluminum
		2. Magnesium
2-20.	Is best known as the red rust	3. Iron and Steel
2-21.	Has white puffy areas	4. Copper
2-22.	Has formation of blue or green salts	
2-23.	Has dark iron oxide coatings which usually form first	

2-24. Which of the following hazards is NOT associated with cleaning solvents?

1. Fire
2. Explosion
3. Breathing
4. Electrical

2-25. Of the following types of dry-cleaning fluids (P-D-680) which, if any, has the higher flash point and is intended for shipboard use?

1. I
2. II
3. III
4. None of the above

2-26. Which of the following substances should be used for cleaning grease from a fabric?

1. Kerosene
2. Soap and water
3. Alcohol
4. Diesel fuel

2-27. How can an internal area that has been sealed off be dehydrated?

1. By installing desiccants
2. By providing drainage
3. By installing a moisture barrier

Learning Objective: Identify a variety of tools used when conducting maintenance on a GMLS.

2-28. What training manual explains how hand tools should be used and emphasizes many safety rules?

1. NAVEDTRA 10188
2. NAVEDTRA 10185
3. NAVPERS 10185
4. NAVPERS 10199

2-29. Which of the following tools is NOT used to apply a striking force?

1. Hammer
2. Prybar
3. Mallet
4. Sledge

2-30. Which of the following wrenches was designed to rotate or hold round work?

1. Pipe
2. Combination
3. Box end
4. Spanner

2-31. What type of wrench is preferred when dealing with nuts and bolts?

1. Adjustable
2. Combination
3. Allen
4. Spanner

2-32. When using the micrometer-type torgue wrench, what is the first step in selecting the desired setting?

1. Lock the grip
2. Adjust the handle to desired position
3. Unlock the grip
4. Install the required socket

In answering questions 2-33 through 2-36, select from column B the cutting tool that fits the description in column A. Responses may be used once, more than once, or not at all.

	A. Descriptions	B. Cutting Tools
2-33.	It is the basic tool used for cutting metal	1. Hacksaw
		2. Chisel
2-34.	It is used to cut or chip metal	3. File
2-35.	A file card is used to clean this tool	
2-36.	Breakage usually occurs if too much pressure is applied on the forward stroke of this tool	

2-37. Which of the following punches has a long taper from its tip to the body and is made to withstand heavy blows?

1. Pin
2. Center
3. Drift
4. Taper

2-38. What type of pliers is used to hold flat or round stock?

1. Needle-nose
2. Combination
3. Round-nosed
4. Diagonal

In answering questions 2-39 through 2-42, select from column B the measuring tool that fits the description in column A.

	A. Descriptions	B. Measuring Tools
2-39.	Measures distances to the nearest one-thousandth of an inch	1. Micrometer
2-40.	Used where accuracy is not critical	2. Thickness gauge
2-41.	Used to check and measure small openings	3. Common rule
2-42.	Has a scale that is divided into 25 equal parts	

2-43. Which of the following micrometers should you use to measure the thickness of a flat surface?

1. Outside
2. Inside
3. Depth

2-44. Which of the following tools is NOT a common portable electrical tool?

1. Impact wrench
2. Drop light
3. Saw
4. Needle gun

● Questions 2-45 through 2-50 are to be judged true or false.

2-45. Before a power tool is plugged in, be sure the switch is in its ON position.

2-46. Never try to clear jammed machinery until the power source has been removed.

2-47. A three-conductor power cord and a three-prong plug should always be used.

2-48. A power cord that is damaged should be repaired.

2-49. If a trouble light is required, a light guard must be installed.

2-50. You should disconnect the pneumatic tool prior to closing the control valve.

2-51. When referring to a 1 inch 8-32 NC hex head bolt, since the first number indicates the length, what would the next two numbers identify?

1. Diameter
2. Pitch
3. Both 1 and 2 above
4. Type of material

2-52. Which of the following methods is the most positive and satisfactory means of securing various fasteners?

1. Cotter pin installation
2. Safety/lock wiring
3. Soldering
4. Welding

2-53. Which of the following methods of safety wiring is recommended for ordnance work?

1. Double-twist
2. Single-wire only
3. Triple-twist only
4. Single-wire and triple-twist

2-54. Of the following plier types, which one is designed to hold, twist, and cut safety wire?

1. Vise grip
2. Regular
3. Diagonal
4. Wire twister

● Questions 2-55 through 2-57 are to be judged true or false.

2-55. Safety wire can be used over and over again.

2-56. Installed safety guards should NOT interfere with moving components.

2-57. Fasteners should be tightened after safety wire installation.

2-58. What type of top is used when starting a tapping operation?

1. Starting
2. Bottom
3. Taper
4. Plug

2-59. Which of the following lubricants is preferred when tapping in steel?

1. White lead paste
2. Straight lard oil
3. A 50-50 mixture of white lead and lard oil
4. A 50-50 mixture of white lead and a general-purpose grease

2-60. A die is used to cut which of the following types of thread?

1. External female
2. External male
3. Internal female
4. Internal male

2-61. What is used to control the depth of the threads that an adjustable round split die cuts?

1. Setscrew
2. Adjusting screw
3. Diestock
4. Chamfer

● Questions 2-62 through 2-64 are to be judged true or false

2-62. When grinding or chipping, it is recommended that you wear appropriate eye protection.

2-63. Whenever you are working with a crane, you should wear a hard hat.

2-64. Eye protection must be worn when you are using any type of power tool.

Learning Objective: Describe the maintenance procedures used on electrical and electronic equipments.

2-65. What source will provide the instructions for inspecting and cleaning the equipments electrical system?

1. OPs
2. ODs
3. MRCs
4. MIPs

2-66. The integrity of electrical components located in the launcher guide and carriage structure is NOT affected by which of the following conditions?

1. Temperature fluctuations
2. Pressure
3. Rain
4. Heat buildup

2-67. What is the recommended cleaning substance for air filters?

1. Alcohol
2. Dry-cleaning solvent
3. Kerosene
4. Soapy water

2-68. Which of the following conditions presents the biggest problem for shipboard equipment?

1. Oil
2. Moisture
3. Dirt
4. Lint

2-69. When moisture is present inside electrical equipments, what is initially used to dry the equipment?

1. LP air
2. Installed ventilation
3. Hot-air blower
4. Dry-cleaning solvent

Assignment 3

General Maintenance (continued); Troubleshooting and Testing

Testbook, NAVEDTRA 10189: Pages 10-45 through 11-38

Learning Objective: Identify the procedures and skills required when working with wire.

3-1. What are the two metals most often used to form soft solder?

1. Lead and antimony
2. Tin and lead
3. Bismuth and tin
4. Tin and cadmium

3-2. Why is flux used in the cleaning process?

1. It acts as a cleaning agent to remove oxidation
2. It acts as the bonding agent between the solder and metal
3. It dilutes the molten solder and allows it to flow
4. It forms a conductive bond between the metal and the solder

3-3. Why do the nuts and screws which hold the tips to soldering guns loosen?

1. The trigger is depressed for too long a period
2. The gun is pulsed too often
3. The heating and cooling cycles loosen them
4. The gun is used for soldering items beyond its capacity

3-4. For which of the following reasons is antisieze compound used with the type of pencil iron that is equipped with removable tips?

1. To allow the tip to be easily removed
2. To prevent the tip from loosening during repeated soldering operations
3. To minimize the number of times the tip must be retinned
4. Each of the above

3-5. Why are heat shunts used in the soldering process?

1. To conduct heat from the component being soldered back to the iron
2. To increase the temperature of the soldering iron or gun
3. To prevent damage to adjacent heat-sensitive components
4. To decrease the temperature to the conductor being soldered

3-6. What is the correct procedure for removing excess solder from a soldering iron?

1. Striking the iron on a solid object
2. Swinging the iron rapidly
3. Scraping the iron with a knife
4. Wiping the iron with a damp cloth or sponge

3-7. What generally causes a disturbed solder joint?

1. Movement of the soldered parts during the cooling process
2. Application of too much heat to the parts
3. Introduction of impurities to the joint from dirty solder or flux
4. Application of too much solder to the joint.

3-8. The preferred method of removing insulation from most types of insulated wire is by the use of

1. a razor blade
2. electrician's pliers
3. a wire stripper
4. a knife

3-9. What are the two basic requirements for a splice or terminal connection?

1. Mechanically and electrically effective
2. Connectors be preinsulated and nonconductive
3. Minimum cost and maximum efficiency
4. Circuit continuity and minimum cost

3-10. For which of the following reasons is the crimped terminal generally used in place of the soldered terminal?

1. Connections can be made more rapidly
2. Less operator skill is required
3. Connections are more uniform in construction
4. Each of the above

3-11. How many basic types of solder-type terminal connectors are used on ordnance equipment?

1. Five
2. Six
3. Three
4. Four

3-12. When you prepare a wire for soldering to a connector terminal, how many turns of wire should you wrap around the terminal?

1. One
2. One and one-half
3. Two
4. Two and one-half

3-13. For which of the following reasons are conductors laced together?

1. To present a neat appearance
2. To help support each other
3. To aid in tracing conductors
4. Each of the above

3-14. Although it may be used, why is the use of round cord discouraged for lacing conductors?

1. It is bulkier than the flat type
2. It is more difficult to handle
3. It is not fungus resistant
4. It has a tendency to cut into wire insulation

● Questions 3-15 through 3-17 are to be judged true or false.

3-15. It is permissible to twist conductors together prior to lacing.

3-16. To make a good connection you have to wrap the stripped wire around the terminal two or three times.

3-17. When making two Western Union splices in a two-conductor cord, the connections must be staggered.

Learning Objective: Define troubleshooting and describe the various procedures for logically finding and correcting a casualty.

3-18. Logical troubleshooting is a procedure in which the technician systematically

1. replaces all units of the equipment that might be at fault
2. singles out the exact cause of the problem
3. substitutes known good components for suspect ones, one at a time
4. makes continuity checks of all wiring

When answering questions 3-19 through 3-22, select from column B the problem area that is described in column A. Responses may be used once, more than once, or not at all.

	A. Descriptions	B. Problem Areas
3-19.	A relay coil burns open	1. Malfunction without breakdown
3-20.	A ground in the control system	2. Operator error
3-21.	An electrical plug vibrates loose	3. Part failure
3-22.	A switch is turned to the wrong position	

● Questions 3-23 through 3-25 are to be judged true or false.

3-23. In the initial step of casualty analysis you must have the ability to recognize that a problem has occurred.

3-24. In the third step of casualty analysis you must collect all available data about the problem and its symptoms.

3-25. After collecting all the available data you should list the possible solution for the problem

3-26. Which of the following terms best decribes the approach you should take in performing steps 1 and 2 of the troubleshooting procedure?

1. Observation, circuit isolation, and tube testing
2. Operational evaluation, circuit isolation, and mental decisions
3. Observation, operational evaluation, and visual inspection
4. Observation, circuit isolation, and circuit testing

3-27. In which of the seven steps of the troubleshooting procedure is it recommended that you first use test equipment?

1. One
2. Two
3. Three
4. Four

3-28. In which of the seven steps of the troubleshooting procedure do you hold a series of checks and test different modes of operation?

1. One
2. Two
3. Six
4. Seven

Learning Objective: Describe the various publications available to assist a technician in troubleshooting.

3-29. System troubleshooting documents are designed to help you in how many different ways?

1. One
2. Two
3. Three
4. Four

When answering questions 3-30 through 3-34, select from column B the directory or diagram that is described in column A. Responses may be used once, more than once, or not at all.

	A. Descriptions	B. Directories and Diagrams
3-30.	You would locate the status lamp in question in this document	1. Indicator fault directory
3-31.	It requires you to answer a series of branching questions about an observed problem	2. Test fault directory 3. Fault logic diagram
3-32.	It is used to study, analyze, and isolate system faults	4. System functional diagram
3-33.	When an SMT fails, it is the first troubleshooting document consulted	
3-34.	It contains all the information necessary to understand and troubleshoot a particular mode or phase of system operation	

3-35. In what chapter of a GMLS OP will a summary signal flow diagram be located?

1. Six
2. Two
3. Three
4. Five

3-36. The operation of a GMLS can be divided into how many basic functions?

1. Five
2. Seven
3. Nine
4. Eleven

3-37. How, or where, is a specific operation represented on an SSFD?

1. In a rectangular box
2. In a circle
3. On the top half of the diagram
4. On an MTO

3-38. How many different types of fault isolation tables are there?

1. Five
2. Two
3. Three
4. Four

3-39. Which of the following documents provides a complete and logical sequence for isolating equipment problems?

1. Signal flow tables
2. Reference diagrams
3. Fault isolation tables
4. System functional diagrams

3-40. In which of the following documents will the electrical components of the system be listed in alphanumeric order?

1. Electrical listing
2. Component listing
3. Internal wiring diagram
4. Cable listing

When answering questions 3-41 through 3-45, select from column B the listing that fits the description in column A. Responses may be used once, more than once, or not at all.

A. Descriptions

3-41. It helps you understand the physical arrangement and functional operation of the system

3-42. It shows the functional arrangement of a circuit

3-43. It shows the point-to-point wiring connections inside an electrical panel

3-44. It shows the external cabling arrangement for each cable in the GMLS

3-45. It lists test points that are safe and easy to reach

B. Listings

1. Internal wiring diagram
2. Electrical schematic diagram
3. Hydraulic schematic diagram
4. Interconnection cabling information

3-46. What type of listing provides detailed information about each cable in the GMLS?

1. An internal wiring diagram
2. A cable listing
3. An electrical schematic
4. A component listing

Learning Objective: Identify the function and characteristics of test equipment on a GMLS.

3-47. Circuit measurement is used for which of the following purposes?

1. To find the weight of a circuit
2. To increase the power used in a circuit
3. To discover the length and width of a circuit
4. To determine the reason a circuit is not functioning properly

3-48. According to Ohm's law, what formula should be used to calculate circuit voltage if resistance and current values are known?

1. $E = \frac{R}{I}$
2. $E = \frac{I}{R}$
3. $E = IR$
4. $E = \frac{1}{IR}$

3-49. An in-circuit meter is used for which of the following purposes?

1. To reduce circuit losses
2. To monitor circuit operation
3. To control power to a circuit
4. To prevent circuit overload conditions

3-50. A multimeter can be used to measure which of the following electrical properties?

1. Voltage
2. Current
3. Resistance
4. Each of the above

3-51. The function switch on a multimeter performs which of the following functions?

1. Selection of the meter range
2. Determination of the proper scale
3. Selection of a.c. or d.c. capability
4. Changing the meter movement from an ammeter to a voltmeter

3-52. When a multimeter is not in use and it is returned to storage, on which of the following positions should the meter be set?

1. +d.c.; highest voltage range
2. -d.c.; higher resistance range
3. A.c.; highest voltage range
4. A.c.; highest current range

3-53. Why is there a mirror on the face of a multimeter?

1. To illuminate the meter face
2. To aid in reducing parallax error
3. To reduce the friction between the pointer and the meter face
4. To compensate for the difference in a.c. and d.c. measurements

3-54. Which of the following GMLSs uses an 8800A digital multimeter?

1. Mk 10 Mod 7
2. Mk 13 Mod 4
3. Mk 12 Mod 0
4. Mk 26 Mod 1

3-55. How are ammeters connected in an electrical circuit?

1. In series with the load only
2. In parallel with the load only
3. In series-parallel with the load
4. In accordance with Lenz's law

3-56. What electrical property is measured by an ammeter?

1. Power
2. Current
3. Voltage
4. Resistance

3-57. A voltmeter should be connected in an electrical circuit in what manner?

1. In series with the load only
2. In parallel with the load only
3. In series-parallel with the load
4. In accordanc with Lenz's law

3-58. What voltmeter range should be used for initial measurements?

1. The lowest
2. The highest
3. The mid-scale

3-59. In an energized circuit, what type of test is conducted to determine the opened or closed condition of a switch or relay?

1. Power
2. Current
3. Resistance
4. Voltage

3-60. How should an ohmmeter be connected in an electrical circuit?

1. In series with the load only
2. In parallel with the load only
3. In series-parallel with the load
4. In parallel with the source

3-61. An ohmmeter is used to check for which of the following conditions?

1. Continuity
2. Overheating
3. Overcurrent
4. Undercurrent

3-62. What type of resistance reading will a short circuit condition produce?

1. Infinity
2. Mid-scale
3. Low

3-63. Meggers (megohmmeters) are used to measure which of the following quantities?

1. Low voltage
2. High voltage
3. Low resistance
4. High resistance

3-64. Which of the following safety precautions should be observed when a megger is used?

1. Do not use a d.c. megger to measure circuits that are powered by a.c.
2. Always start with the highest scale selection of the meter
3. Do not touch the meter leads when a measurement is being taken
4. All of the above

3-65. When a megger is used to check the insulation of a wire, which of the following indications should be considered normal?

1. ∞
2. 0
3. 500 V
4. 1000 V

3-66. On which of the following panels is the ground detection meter mounted?

1. EP1
2. EP2
3. EP3
4. EP4

3-67. Which of the following GMLSs uses a TCLS?

1. Mk 10 Mod 0
2. Mk 11 Mod 2
3. Mk 13 Mod 0
4. Mk 13 Mod 5

3-68. When you are using the TCLS, which push-button should you depress to test all of the readout display segments?

1. AT
2. LT
3. MC
4. TC

3-69. Which of the following one-digit status readouts indicates the status of a zero (0) through 377 coded circuit when the -2 test point is low and the -1 test point is high?

1. One
2. Two
3. Three
4. Zero

3-70. What is used to start and stop the timer when you check the cycle time of a circuit?

1. A shift register
2. Two shift registers
3. A multiplexer
4. Two multiplexers

3-71. Which of the following devices is NOT contained in a hydraulic test kit?

1. A test hose
2. A test plug
3. Various pressure gauges
4. Assorted nipples and couplings

Assignment 4

Troubleshooting and Testing (continued)
Explosives, Demolition, and Pyrotechnics

Textbook, NAVEDTRA 10189: Pages 11-39 through 12-35

Learning Objective: Recognize the techniques to be used in troubleshooting and repairing transistorized and printed circuits.

4-1. What is the first step you should take in the troubleshooting procedure for a transistor circuit?

1. Inspect the circuit visually
2. Remove the transistors from the circuit
3. Test the circuit with a signal generator
4. Test the circuit with a multimeter

4-2. What is the maximum amount of current an ohmmeter can safely pass through a transistor circuit under test?

1. 1 ampere
2. 1 milliampere
3. 10 milliamperes
4. 100 milliamperes

4-3. When you are performing front-to-back ratio checks on crystal diodes, what should the minimum ratio be?

1. 5:1
2. 10:1
3. 100:1
4. 500:1

4-4. What type of soldering iron is recommended for use on printed circuits and electronic modules?

1. A large, high-wattage soldering iron
2. A small, low-wattage soldering iron
3. A large, high-voltage soldering iron
4. A small, low-voltage soldering iron

Questions 4-5 and 4-6 are to be judged true or false.

4-5. Do NOT remove or replace a transistor while the battery or power source is connected.

4-6. For every 10°C that the junction temperature of a transistor is raised, the life of the transistor is halved.

4-7. Intermittent conditions in transistor printed circuits are most often caused by what malfunction?

1. Loose terminals
2. Fused conducting strips
3. Defective soldering
4. Arc-over

4-8. You locate a small break in a lacquered conducting strip of a transistor printed circuit. What should you do first?

1. Scrape away the lacquer in the area of the break
2. Cut out the damaged strip
3. Flow solder over the break
4. Bridge the break with a small bare wire

4-9. When do you use insulated wire to repair a defective conducting strip in a transistor printed circuit?

1. When the strip is minutely cracked
2. When the strip looks like it might peel
3. When the strip is fused or burned out
4. When no new strip is available

4-10. Carbonized areas that could form leakage paths on a printed-circuit board should be cleaned, if possible, with a solvent and a

1. dry rag
2. stiff brush
3. needle probe
4. drill

4-11. What is the most common cause of broken circuit boards?

1. Overheating
2. Excessive voltage
3. Improper flexing
4. Careless handling

Learning Objective: Identify the procedures used in aligning synchro systems.

4-12. What are the two general classifications of synchro systems?

1. Torque and load
2. Torque and control
3. Load and control
4. Load and lock

4-13. What is the reference point for the alignment of all synchro units?

1. Mechanical zero
2. Electrical zero
3. Mechanical null
4. Electrical null

4-14. What is the best method of aligning a synchro?

1. The d.c. voltmeter method
2. The a.c. voltmeter method
3. The synchro-tester method
4. The electro-zero method

4-15. A synchro is zeroed by the use of a synchro tester. After it is zeroed, the S1 and S3 leads are shorted together, and the synchro tester dial moves. What does this indicate?

1. The synchro is zeroed correctly
2. The synchro is not zeroed correctly
3. The supply voltage is too low
4. The supply voltage is too high

- When answering question 4-16, refer to textbook figure 11-41.

4-16. When using a voltmeter to make the fine setting on a torque transmitter (TX), between which synchro leads is the voltmeter connected?

1. S2 and R2
2. S3 and R2
3. S1 and S3
4. S1 and S2

4-17. When a 115-volt source is used during the alignment of a synchro, what is the maximum time the circuit can be energized without causing damage to the synchro?

1. 1 minute
2. 2 minutes
3. 15 minutes
4. 30 minutes

4-18. If a synchro is found to have bad bearings, which of the following actions should be taken?

1. Replace the bearings
2. Lubricate the synchro
3. Replace the synchro
4. Continue to use it

4-19. Which of the following troubles is common in newly installed synchro systems?

1. Dirty brushes
2. Improper wiring
3. Worn slip rings
4. Shorted synchro windings

Learning Objective: Identify the types of tests and the equipment used for checking the performance of the launcher power drives.

4-20. Which of the following operations must you perform to motion-test the power drive of a launcher?

1. Place it in operation, and test the servo with a megger and voltmeter
2. Remove the servosystem, and operate it on a special test stand
3. Disconnect the launcher from the computers and test the power drive with a dummy director and error recorder
4. Perform all of the above operations in the sequence given

4-21. What is the source of velocity signals in a dummy director?

1. Main servo
2. Auxiliary servo
3. 36-speed control transformer
4. Tach generator

4-22. A launcher power drive servo functions as well as can be expected if a performance test indicates that

1. the launcher follows a 10° per second constant velocity signal without lag or lead
2. the power drive performs in accordance with the acceptance test recorded in the ship's records
3. the servo's maximum error is not more than 5 minutes
4. no hunting or overtravel of the launcher occurs during a complete cycle of operation

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When answering questions 4-23 through 4-26, select from column B the signal that fits the description in column A.

A. Descriptions	B. Signals
4-23. Simulates the kind of power drive order which is produced when the FCS is tracking a target	1. Fixed displacement 2. Constant velocity
4-24. Represents the motions experienced during roll and pitch	3. Simple harmonic motion
4-25. Creates a large instantaneous error for the launcher	
4-26. Used to check how accurately a power drive follows a roll signal	

Learning Objective: Interpret characteristics and terms peculiar to explosives.

4-27. The main distinction between a low explosive and a high explosive depends on what factor?

1. Rate of detonation
2. Rate of decomposition
3. Burning rate
4. Direction of transformation

4-28. Low explosives are mostly ___a___ (solid, liquid) combustible materials that decompose ___b___ (slowly, rapidly) but normally do not explode.

1. (a) liquid (b) rapidly
2. (a) liquid (b) slowly
3. (a) solid (b) rapidly
4. (a) solid (b) slowly

Learning Objective: Identify the various classes of explosives including characteristics, purpose, and use.

4-29. Which of the following groups of explosives is classified according to the explosives' military use?

1. Initiators, propellants, auxiliary, and burster.
2. Initiators, primers, boosters, and propellants.
3. Auxiliary, booster, igniters, and filler charge.
4. Auxiliary, igniters, filler charges, and primers.

4-30. What is/are the state(s) of explosives used as propellants?

1. Solid only
2. Liquid only
3. Solid and liquid only
4. Solid, liquid, and gas

4-31. In some projectiles, what part of the explosive train serves to compensate for the insensitivity of the main charge?

1. Igniter
2. Booster
3. Primer
4. Detonator

4-32. What is the shattering power of an explosive termed?

1. Shock
2. Blast
3. Brisance
4. Hygroscopicity

4-33. The sensitivity of an explosive is defined as its

1. ability to do work
2. rate of doing work
3. weight per unit volume
4. ease of being detonated by whatever means

4-34. Which of the following is a characteristic of a stable explosive?

1. It has a uniform burning rate
2. It will not absorb moisture
3. It is not seriously affected by stowage conditions
4. It is easily detonated

4-35. An explosive reaction would be characterized by its

1. velocity, heat, gases, and shape
2. velocity, heat, gases, and pressure
3. weight, heat, gases, and pressure
4. weight, size, gases, and pressure

4-36. The amount of work an explosive can do depends upon which of the following factors?

1. The amount of pressure created by the explosion only
2. The amount of heat released by the explosion only
3. The amount of heat released and the volume of the gases created by the explosion
4. The amount of time required for the reaction to occur

4-37. When an explosive reaction is of higher velocity, the _____a_____ pressure
minimum, maximum
is reached _____b_____ and is greater.
sooner, later

1. (a) minimum (b) later
2. (a) minimum (b) sooner
3. (a) maximum (b) later
4. (a) maximum (b) sooner

4-38. The most efficient explosives are those that are both

1. cost effective and powerful
2. brisant and powerful
3. brisant and superior
4. abundant and powerful

Learning Objective: Describe the principal service explosives used as propellants, inititators, and burster charges including characteristics and uses.

4-39. Amatol is a mixture of ammonium nitrate and TNT. Because of its composition it is

1. temperature sensitive
2. pressure sensitive
3. hygroscopic
4. dependable

4-40. What type of explosive is ballistite and how is it used?

1. Double-base; rocket propellant
2. Double-base; delay element
3. Single-base; rocket propellant
4. Single-base; igniters

4-41. What is the purpose of the wax in composition A-3?

1. It acts as a sealer and melts easily
2. It acts as a binder and desensitizer
3. It increases the burning rate
4. It decreases the stability

4-42. What type of solution may be used to destroy diazodinotrophenol (DDNP)?

1. Sodium nitrate
2. Sodium cloride
3. Sodium hydroxide
4. Ammonium nitrate

4-43. Dynamite is more hazardous in storage than other high explosives because

1. its high melting point and its reaction to other metals
2. its low melting point and it deteriorates more rapidly than other explosives
3. it may exude nitroglycerin and it reacts with other metals
4. it may exude nitroglycerin and it deteriorates more rapidly than other explosives

4-44. What is the main use of explosive D, and how does it compare with TNT in power and brisance, respectively?

1. In mixture with TNT to form amatol; superior
2. Main charge for projectiles, slightly superior
3. Main charge for projectiles; slightly inferior
4. Main charge for bombs; slightly inferior

4-45. HBX-3 is used primarily in

1. projectiles and bombs
2. projectiles and torpedo warheads
3. mines and bombs
4. mines and torpedo warheads

4-46. Which of the following statements express(es) a characteristic of lead azide?

1. It is poisonous
2. Its impact sensitivity is not reduced by water
3. It may be used where detonation is caused by flame and heat
4. All of the above

4-47. Pentolite is often used as a booster charge in certain types of

1. shaped charges
2. reduced charges
3. full charges
4. rocket motors

4-48. In which of the following ways should smokeless powder be stowed?

1. In airtight containers
2. In moisture-proof containers
3. In temperature-controlled magazines
4. All of the above

Learning Objective: Point out characteristics and terms peculiar to demolition and demolition materials.

4-49. What is the Gunner's Mate's responsibility with respect to demolition and demolition material?

1. Safe handling
2. Stowage and maintenance
3. Use of demolition materials
4. Each of the above

4-50. What publication describes the various devices, explosives and hardwares used in demoltion work?

1. NAVSHIPS OP 2215
2. NAVSHIPS OP 3125
3. NAVSEA OP 2212
4. NAVSEA OP 3125

4-51. Selection of demolition explosives is normally based on

1. sensitivity
2. relative power
3. suitability
4. application

4-52. How is a nonelectric blasting cap set off?

1. By a bridge wire
2. By heat
3. By a spit of flame
4. By percussion

4-53. The rate of detonation in explosive charges is normally expressed in

1. miles per hour
2. feet per minute
3. miles per second
4. feet per second

4-54. The correct term for slow-burning powder-filled cord is a

1. fuze
2. fuse
3. detonating cord
4. firing device

4-55. The term used to measure the free air space between the base of a shaped charge and the target is

1. Munroe effect
2. blasting effect
3. air gap
4. standoff distance

4-56. The booster charge for the Mk 2 demolition charge is what size TNT block?

1. 1 lb
2. 1/2 lb
3. 3 lb
4. 4 lb

4-57. Maximum penetration is obtained when the shaped charge is exploded at a/an

1. target of opportunity
2. optimum distance from the target
3. angle adjacent to the target
4. high elevation

4-58. What enables the Mk 45 shaped charge to penetrate as deeply as it does?

1. A steel cavity liner
2. A plastic cavity liner
3. A rubber cavity liner
4. A copper cavity liner

4-59. The M2A3 shaped charge will penetrate armor plate to a depth of

1. 9 in.
2. 6 in.
3. 3 in.
4. 12 in.

4-60. What is the minimum amount of current required to ignite a special electric delay blasting cap?

1. 1 amp
2. 3/4 amp
3. 1/2 amp
4. 1/4 amp

4-61. The average burn rate for time blasting fuses is between 30 and 45

1. seconds per foot
2. seconds per inch
3. inches per second
4. feet per second

4-62. At what rate does detonating cord transmit a detonating wave from one point to another?

1. 2,600 feet per second
2. 2,600 feet per minute
3. 26,000 feet per second
4. 26,000 feet per minute

4-63. When you use the 10 cap blasting machine, the blasting caps must be connected in

1. series
2. parrallel
3. a circle

4-64. What should you test during a demolition charge test if electric caps are being used?

1. Both cable connectors after they have been connected to the caps
2. Both cable connectors after they have been twisted together
3. Both cable connectors before they have been connected to the caps
4. One cable connector after it has been connected to the cap

4-65. If a misfire occurs, you should try firing once again. If the second attempt still fails, what should you do?

1. Make a third attempt
2. Remove the blasting machine handle and put it in your pocket
3. Reset the blasting caps in the charger
4. Disconnect the firing leads and light them with a match

Learning Objective: Outline general characteristics, uses, and safety practices in stowing and handling pyrotechnics.

4-66. Pyrotechnics that have a significant amount of low explosives are marked with a narrow band colored as follows:

1. brown
2. yellow
3. blue
4. white

4-67. Most pyrotechnic devices have been designed to withstand temperatures from

1. -30° to 130°F
2. -65° to 130°F
3. -65° to 160°F
4. -100° to 160°F

4-68. Navy lights that give off a vinegary odor should be disposed of by

1. returning them to the nearest ammunition depot
2. dumping them overboard in a weighted sack
3. igniting each one and then throwing them overboard
4. burning them in an incinerator

4-69. Which of the following pyrotechnic units can be used both at night and during the day?

1. Mk 1 Mod 0 Navy light
2. Mk 1 Mod 1 Navy light
3. Mk 13 Mod 0 marine illumination signal
4. Mk 79 Mod 5 marine illumination signal

4-70. The Mk 79 Mod 0 signal kit shown in figure 12-24 of the text is designed to be used by downed aircrew personnel and contains which of the following pyrotechnic devices?

1. The Mk 24 Mod 0 projector and seven Mk 45 Mod 0 signals
2. The Mk 31 Mod 0 projector and seven Mk 80 Mod 0 signals
3. The Mk 31 Mod 0 projector and the Mk 31 Mod 0 signal
4. Seven Mk 31 Mod 0 signals and seven Mk 31 Mod 0 projectors

4-71. The Mk 5 pyrotechnic pistol is used to fire the

1. Mk 1 Mod 0 Navy light
2. Mk 1 Mod 1 marine illumination signal
3. Mk 2 marine illumination signal
4. Mk 11 aircraft illumination signal

4-72. The M11 aircraft illumination signal is designed to be fired from the

1. AN-M8 pyrotechnic pistol
2. AN-M45 pyrotechnic pistol
3. AN-M5 pyrotechnic pistol
4. Mk 31 Mod 0 projector

4-73. The M11 aircraft illumination signal utilizes a parachute that provides a suspended rate of fall at about

1. 8 feet per second
2. 2 feet per second
3. 6 feet per second
4. 4 feet per second

4-74. The Mk 2 marine location marker is hand launched from surface or aircraft for

1. daytime marking purposes at sea
2. daytime signaling at sea
3. nighttime marking aboard ship
4. nighttime marking purposes at sea

4-75. What is used to activate the battery on the Mk 58 marine location marker?

1. Seawater
2. Fresh air
3. Flame
4. Igniter

Assignment 5

Small Arms and Machine Guns

Textbook, NAVEDTRA 10189: Pages 13-1 through 13-27

Learning Objective: Define descriptive terms used in small arms and the steps in the small arms cycle of operation.

5-1. As used in the Navy, the term "small arms" defines weapons with a caliber equal to or smaller than

1. 0.60 in.
2. 0.72 in.
3. 0.75 in.
4. 0.80 in.

5-2. The Army designation "MIAI" on a weapon provides the same information given in Navy nomenclature by the

1. mark number and caliber
2. mark number only
3. caliber and mod number only
4. mark number and mod number

5-3. Assume that you melt down a pound of lead and form it into 12 balls of equal weight. Which of the following statements correctly describes each ball?

1. It has the same diameter as the bore of a 12-gauge shotgun
2. It is the same weight as a 12-gauge shotgun charge
3. It has a diameter of 0.271
4. It is 0.729 times as heavy as a 12-gauge shotgun charge

In answering questions 5-4 through 5-18, select from column B the description of each small arm's component in column A. Responses may be used once, more than once, or not at all.

PART I

A. Components	B. Descriptions
5-4. Battery	1. The extreme aft end of the barrel
5-5. Barrel	2. The hole running the length of the barrel
5-6. Breech	3. The metal tube through which the projectile travels
	4. The normal position of all moving parts

PART II

A. Components	B. Descriptions
5-7. Cook-off	1. Pressure in the chamber from expanding gases
5-8. Ejector	2. The part that removes the empty case from the bolt
5-9. Extractor	3. Functioning of a round in a hot chamber
	4. Pulls the fired case from the chamber

PART III

	A. Components		B. Descriptions
5-10.	Hangfire	1.	The device driven against the primer to fire a round
5-11.	Misfire	2.	A delay in the functioning of a fired round
5-12.	Firing pin	3.	Failure of a round to fire
		4.	The greatest distance a weapon can fire

PART IV

	A. Components		B. Descriptions
5-13.	Rate of fire	1.	The number of rounds a weapon can fire in 1 minute
5-14.	Sustained rate of fire	2.	The speed at which the projectile leaves the muzzle
5-15.	Cycle rate of fire	3.	The number of rounds fired within 1 minute
		4.	The rate of fire a weapon can deliver for an indefinite period

PART V

	A. Components		B. Descriptions
5-16.	Safety device	1.	A characteristic built into a weapon that prevents inadvertent firing
5-17.	Sear	2.	The component that imparts a spin to the projectile
5-18.	Safety feature	3.	The part that holds the firing pin in a cocked position
		4.	A manually actuated lock that prevents the weapon from firing

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Learning Objective: Describe principles of operation of small arms weapons.

● Question 5-19 is to be judged true or false

5-19. Most modern small arms are fired by percussion

5-20. When a weapon is cocked, what component holds it in that position?

1. Firing pin
2. Sear
3. Hammer
4. Bolt

Learning Objective: Define the steps in the small arms cycle of operation.

In answering questions 5-21 through 5-28, select from column B the action that occurs during each step of the small arms cycle of operations in column A. Responses may be used once, more than once, or not at all.

PART I

A. Steps	B. Actions
5-21. Feeding	1. Holding the bolt in position until the bullet leaves the muzzle
5-22. Chambering	2. Placing a round into the receiver
5-23. Locking	3. Striking the cartridge primer with the firing pin or hammer
	4. Placing the round into the chamber

PART II

A. Steps	B. Actions
5-24. Firing	1. Striking the cartridge primer with the firing pin or hammer
5-25. Unlocking	2. Retracting the firing pin or hammer and setting it for firing
5-26. Extracting	3. Freeing the bolt so it can move rearward
	4. Pulling the empty cartridge case free of the chamber

PART III

A. Steps	B. Actions
5-27. Ejecting	1. Freeing the bolt so it can move rearward
5-28. Cocking	2. Throwing the empty cartridge case free of the receiver
	3. Retracting the firing pin or hammer and setting it for firing
	4. Placing a cartridge into the receiver

Learning Objective: Identify different kinds of operating systems used in small arms.

5-29. In a small arms weapon, on what is the type of operating system based?

1. The type of feeding system
2. The type of firing mechanism used
3. The source of energy for its operation
4. The number of rounds it can fire with one squeeze of the trigger

● The following answers are for questions 5-30 through 5-32.

1. Recoil
2. Spring
3. Gas
4. Blowback

5-30. When a weapon is fired, the expanding gases from the fired cartridge strike a piston to cause it and the other recoiling parts to move to the rear, thereby unlocking and cocking the weapon and extracting and ejecting the cartridge case. What type of operation is described?

5-31. When a weapon is fired and the propellant in the cartridge case explodes, the pressure created exerts itself to the rear against the breech. That action causes the bolt and barrel, which are locked together for a short time, to move to the rear against spring pressure, causing extraction and ejection of the cartridge case and cocking of the weapon. The compressed spring then completes the cycle of operation. What type of operation is described?

5-32. When a weapon is fired, the force of the exploding propellant drives the bolt, which is not locked to the barrel, to the rear and compresses the recoil spring. The recoil spring returns and positions the bolt to force a new round into the chamber. What type of operation is described?

Learning Objective: Describe component parts, disassembly and assembly procedures, and principles of operation and functioning of the .45-caliber pistol.

5-33. Which of the following phrases best describe the .45-caliber pistol?

1. Fully automatic, gas-operated, magazine-fed, self-loading
2. Fully automatic, recoil-operated, clip-fed, with adjustable sights
3. Semiautomatic, recoil-operated, magazine-fed, self-loading
4. Semiautomatic, gas-operated, clip-fed with adjustable sights

5-34. Which of the following features of the .45-caliber pistol is unique among Navy small arms?

1. Its maximum range
2. Its effective range
3. Its direction of rifling twist
4. Its type of feeding

● Questions 5-35 through 5-38 pertain to disassembly and assembly of the .45-caliber pistol and its nomenclature.

5-35. In field-stripping this pistol, which of the following parts do you NOT remove?

1. Hammer
2. Barrel link
3. Firing pin stop
4. Extractor

5-36. Prior to disassembly or any other work on the .45-caliber pistol, you must take which of the following actions?

1. Remove the magazine and pull the slide to the rear for inspection of the chamber
2. Engage the safety lock and move the hammer forward
3. Pull the slide to the rear and release
4. Pull the slide to the rear, engage the slide stop, and then remove the magazine

5-37. In checking the safety features on the .45-caliber pistol, what step(s) should you take?

1. Ensure the weapon is empty
2. Keep the weapon pointed in a safe direction
3. Both 1 and 2 above
4. Check all features at the same time by pulling trigger while gripping the weapon firmly and pointing the weapon down range

5-38. In field stripping the .45-caliber pistol, you remove which of the following parts?

1. Barrel bushing, barrel, barrel slide, and extractor only
2. Barrel bushing, barrel, barrel link, barrel link pin, slide, extractor, firing pin, firing pin spring and the firing pin stop
3. Recoil spring plug, recoil spring, recoil spring guide, and the slide stop
4. Both 2 and 3 above

5-39. Which of the following parts is considered to be an automatic safety?

1. Safety lock
2. Half-cock notch
3. Grip safety
4. Thumb safety

For questions 5-40 through 5-42, select from column B the functions of the pistol safety devices in column A. Responses may be used once, more than once, or not at all.

	A. Safety Devices	B. Functions
5-40.	Safety lock	1. Blocks sear and trigger movement unless the grip safety is depressed
5-41.	Half-cock notch	2. Prevents firing unless the slide is fully forward and locked
5-42.	Disconnector	3. Blocks a cocked hammer and locks a closed slide
		4. Prevents the sear from disengaging the hammer even though the trip safety and trigger are depressed

5-43. Refer to the textbook figure 13-8, view A. A condition in which the sear and disconnector are disengaged, as shown, results when which of the following actions occur?

1. The slide is not all the way forward and locked
2. The slide is locked in its forward position
3. The grip safety is not depressed
4. The hammer is at half-cock position

● Questions 5-44 through 5-49 pertain to the cycle of operation and functioning of the .45-caliber pistol. Assume that the pistol has a full magazine inserted and the round in the chamber has just been fired by depressing the trigger and grip safety.

5-44. The slide and barrel that are locked together at the beginning of recoil are unlocked from each other by action of which of the following parts?

1. The disconnector
2. The slide stop lug
3. The barrel link
4. The safety lock

5-45. Ejection of the cartridge case occurs during ________a________ as the case
recoil, counterrecoil
strikes ____________b____________
part II, a stationary part on the receiver
illustrated in textbook figure 13-6.

1. (a) recoil (b) a stationary part on the receiver
2. (a) recoil (b) part II
3. (a) counterrecoil (b) a stationary part on the receiver
4. (a) counterrecoil (b) part II

● When answering question 5-46, refer to textbook figure 13-6.

5-46. When the pistol is fired, spring 17 is compressed by which of the following actions?

1. Recoil through the sear and disconnector
2. Recoil through the hammer and hammer strut
3. Counterrecoil through the hammer and hammer strut
4. Counterrecoil through the hammer and hammer strut

5-47. When does the feeding step begin?

1. When the slide clears the top of the magazine in recoil
2. As the slide starts forward in counterrecoil
3. When the slide clears the top of the magazine in counterrecoil
4. As the forward end of the round starts up the ramp

5-48. After the round is fully chambered, what further action in counterrecoil, if any, occurs?

1. The barrel unlocks from the slide and continues forward
2. The extractor is forced over the rim of the cartridge case
3. The slide continues forward a small distance after which the barrel is pivoted upward and forward
4. None

5-49. What part provides the force to cause the firing pin to strike the primer and fire the round?

1. Firing pin spring
2. Sear spring
3. Recoil spring
4. Mainspring

Learning Objective: Point out component parts, disassembly and assembly procedures, and principles of operation of the .38-caliber Smith and Wesson revolver.

● When answering questions 5-50 and 5-51, refer to textbook figure 13-11.

5-50. In preparation for loading the revolver, how is the cylinder swung out?

1. By pushing in on part 12 and tipping the revolver to the left
2. By pulling back on part 9 as you tip the revolver to the right
3. By pushing forward on the thumbpiece and applying pressure on the left side of part 15
4. By pushing forward on the thumbpiece and applying pressure on the right side of part 15

5-51. To load the revolver, you must have the hammer in the ___a___ position to
fired, cocked
permit disengagement of the
___b___ from part 15.
sear, thumbpiece

1. (a) fired (b) sear
2. (a) fired (b) thumbpiece
3. (a) cocked (b) sear
4. (a) cocked (b) thumbpiece

● When answering question 5-52, use the following alternatives.

A. The revolver continues to fire as long as you hold the trigger depressed
B. You cock the hammer by hand and pull the trigger for each firing; cocking action rotate the cylinder
C. You pull and release the trigger for each round fired; the hammer cocks automatically and rotates the cylinder when you pull the trigger enough to release the sear from the hammer
D. For each round fired, you pull the trigger, which rotates the cylinder and raises the hammer.
E. After firing a round, you must push forward on the thumbpiece and rotate the cylinder by hand to permit firing of another round

5-52. Which two statements best describe single-action and double-action firing respectively?

1. B; A
2. B; D
3. E; A
4. E; C

5-53. What part of the revolver prevents firing (a) when a loaded revolver is dropped or struck on its hammer, and (b) when the hammer slips from the operator's thumb during cockcing?

1. (a) hammer block (b) rebound slide
2. (a) hammer block (b) thumbpiece
3. (a) rebound slide (b) hammer block
4. (a) rebound slide (b) thumbpiece

5-54. What should be your first step in disassembling the revolver?

1. Cock the hammer
2. Remove the stocks
3. Push forward on the thumbpiece
4. Swing the cylinder out to the right

● When answering questions 5-55 and 5-56, refer to textbook figure 13-11.

5-55. Parts 15, 16, and 17 are removed as one unit after you first remove

1. part 5
2. part 13
3. part 1
4. the sideplate screw directly below the cylinder

5-56. To assemble the late model revolver, what is your first step?

1. Install part 6 to the receiver
2. Install parts 15, 16 and 17 to part 2
3. Install part 2 to the receiver
4. Install part 3 over part 12

Learning Objective: Point out component parts, and disassembly of the .38-caliber Ruger Service-Six revolver.

5-57. How many safety features are incorporated into the revolver?

1. One
2. Two
3. Three
4. Four

5-58. What should be your third step in disassembling the revolver?

1. Remove the grip screw
2. Remove the disassembly pin
3. Cock the hammer
4. Open the cylinder

5-59. What component should you use to depress the trigger guard lock plunger?

1. Hammer strut
2. Cylinder
3. Hammer pivot
4. Disassembly pin

Learning Objective: Identify the parts, controls, disassembly and assembly procedures, principles of operation and functioning of the M14 rifle.

5-60. How is the M14 rifle cooled, operated, and fed?

1. Air-cooled, gas operated, magazine-fed
2. Air-cooled, recoil-operated, magazine-fed
3. Water-cooled, gas-operated, clip-fed
4. Water-cooled, recoil-operated, clip-fed

5-61. How is a loaded magazine installed in the M14 rifle?

1. By inserting the rear end of the magazine into the magazine well until it is engaged by the rear catch, then pushing forward and up on the magazine
2. By inserting the front end of the magazine into the magazine well until it is engaged by the front catch, then pulling to the rear and up on the magazine
3. By inserting the magazine into the magazine well and tapping it lightly on the bottom
4. By inserting the magazine all the way into the magazine well after the bolt has been pulled to the rear, and sliding it straight to the rear

5-62. What is the function of the M14 rifle's gas spindle valve?

1. To control recoil and counterrecoil
2. To regulate the speed of firing
3. To increase or decrease range
4. To control the gases used in firing

5-63. The M14 rifle's adjustable rear sight windage knob is turned clockwise to move the sight to the ____a____ and
right, left
the pinion is rotated clockwise to move the sight aperture ___b___ .
up, down

1. (a) right (b) up
2. (a) right (b) down
3. (a) left (b) up
4. (a) left (b) down

5-64. What action is taken to ensure that the M14 rifle will NOT fire automatically?

1. A modified type of magazine is inserted
2. The selector is replaced with the selector shaft lock
3. The bolt is modified to permit only semiautomatic fire
4. A different firing mechanism is used in place of the regular one

- For questions 5-65 and 5-67, assume you are firing the M14 rifle.

5-65. Your rifle is equipped with a selector shaft lock. After squeezing the trigger to fire one round, you wish to fire the remaining rounds. What must you do?

1. Hold your finger on the trigger
2. Move the operating rod handle all the way to the rear and release for each round
3. Pull the safety back and squeeze the trigger
4. Release the trigger and squeeze it once for each round

5-66. To unload the rifle after firing, what is the first thing you should do?

1. Pull the operating rod handle all the way to the rear
2. Remove the magazine
3. Push the safety rearward into the trigger guard
4. Push the operating rod handle all the way forward

5-67. Besides an empty chamber, which of the following conditions must be present before the rifle is considered clear?

1. Bolt carrier locked to the rear
2. Magazine removed
3. Safety on SAFE position
4. Each of the above

- Questions 5-68 through 5-72 pertain to disassembly, assembly, and nomenclature of the M14 rifle.

5-68. Disassembly to the extent shown in textbook figure 13-21 is recommended for which of the following purposes?

1. For cleaning, lubricating, and maintenance
2. For stowing
3. For transporting
4. All of the above

5-32. When a weapon is fired, the force of the exploding propellant drives the bolt, which is not locked to the barrel, to the rear and compresses the recoil spring. The recoil spring returns and positions the bolt to force a new round into the chamber. What type of operation is described?

Learning Objective: Describe component parts, disassembly and assembly procedures, and principles of operation and functioning of the .45-caliber pistol.

5-33. Which of the following phrases best describe the .45-caliber pistol?

1. Fully automatic, gas-operated, magazine-fed, self-loading
2. Fully automatic, recoil-operated, clip-fed, with adjustable sights
3. Semiautomatic, recoil-operated, magazine-fed, self-loading
4. Semiautomatic, gas-operated, clip-fed with adjustable sights

5-34. Which of the following features of the .45-caliber pistol is unique among Navy small arms?

1. Its maximum range
2. Its effective range
3. Its direction of rifling twist
4. Its type of feeding

● Questions 5-35 through 5-38 pertain to disassembly and assembly of the .45-caliber pistol and its nomenclature.

5-35. In field-stripping this pistol, which of the following parts do you NOT remove?

1. Hammer
2. Barrel link
3. Firing pin stop
4. Extractor

5-36. Prior to disassembly or any other work on the .45-caliber pistol, you must take which of the following actions?

1. Remove the magazine and pull the slide to the rear for inspection of the chamber
2. Engage the safety lock and move the hammer forward
3. Pull the slide to the rear and release
4. Pull the slide to the rear, engage the slide stop, and then remove the magazine

5-37. In checking the safety features on the .45-caliber pistol, what step(s) should you take?

1. Ensure the weapon is empty
2. Keep the weapon pointed in a safe direction
3. Both 1 and 2 above
4. Check all features at the same time by pulling trigger while gripping the weapon firmly and pointing the weapon down range

5-38. In field stripping the .45-caliber pistol, you remove which of the following parts?

1. Barrel bushing, barrel, barrel slide, and extractor only
2. Barrel bushing, barrel, barrel link, barrel link pin, slide, extractor, firing pin, firing pin spring and the firing pin stop
3. Recoil spring plug, recoil spring, recoil spring guide, and the slide stop
4. Both 2 and 3 above

5-39. Which of the following parts is considered to be an automatic safety?

1. Safety lock
2. Half-cock notch
3. Grip safety
4. Thumb safety

For questions 5-40 through 5-42, select from column B the functions of the pistol safety devices in column A. Responses may be used once, more than once, or not at all.

A. Safety Devices

5-40. Safety lock

5-41. Half-cock notch

5-42. Disconnector

B. Functions

1. Blocks sear and trigger movement unless the grip safety is depressed
2. Prevents firing unless the slide is fully forward and locked
3. Blocks a cocked hammer and locks a closed slide
4. Prevents the sear from disengaging the hammer even though the trip safety and trigger are depressed

5-43. Refer to the textbook figure 13-8, view A. A condition in which the sear and disconnector are disengaged, as shown, results when which of the following actions occur?

1. The slide is not all the way forward and locked
2. The slide is locked in its forward position
3. The grip safety is not depressed
4. The hammer is at half-cock position

- Questions 5-44 through 5-49 pertain to the cycle of operation and functioning of the .45-caliber pistol. Assume that the pistol has a full magazine inserted and the round in the chamber has just been fired by depressing the trigger and grip safety.

5-44. The slide and barrel that are locked together at the beginning of recoil are unlocked from each other by action of which of the following parts?

1. The disconnector
2. The slide stop lug
3. The barrel link
4. The safety lock

5-45. Ejection of the cartridge case occurs
during ________a________ as the case
recoil, counterrecoil
strikes ________b________
part II, a stationary part on the
________ illustrated in textbook
receiver
figure 13-6.

1. (a) recoil (b) a stationary part on the receiver
2. (a) recoil (b) part II
3. (a) counterrecoil (b) a stationary part on the receiver
4. (a) counterrecoil (b) part II

- When answering question 5-46, refer to textbook figure 13-6.

5-46. When the pistol is fired, spring 17 is compressed by which of the following actions?

1. Recoil through the sear and disconnector
2. Recoil through the hammer and hammer strut
3. Counterrecoil through the hammer and hammer strut
4. Counterrecoil through the hammer and hammer strut

5-47. When does the feeding step begin?

1. When the slide clears the top of the magazine in recoil
2. As the slide starts forward in counterrecoil
3. When the slide clears the top of the magazine in counterrecoil
4. As the forward end of the round starts up the ramp

5-48. After the round is fully chambered, what further action in counterrecoil, if any, occurs?

1. The barrel unlocks from the slide and continues forward
2. The extractor is forced over the rim of the cartridge case
3. The slide continues forward a small distance after which the barrel is pivoted upward and forward
4. None

5-49. What part provides the force to cause the firing pin to strike the primer and fire the round?

1. Firing pin spring
2. Sear spring
3. Recoil spring
4. Mainspring

Learning Objective: Point out component parts, disassembly and assembly procedures, and principles of operation of the .38-caliber Smith and Wesson revolver.

- When answering questions 5-50 and 5-51, refer to textbook figure 13-11.

5-50. In preparation for loading the revolver, how is the cylinder swung out?

1. By pushing in on part 12 and tipping the revolver to the left
2. By pulling back on part 9 as you tip the revolver to the right
3. By pushing forward on the thumbpiece and applying pressure on the left side of part 15
4. By pushing forward on the thumbpiece and applying pressure on the right side of part 15

5-51. To load the revolver, you must have the hammer in the _____a_____ position to
fired, cocked
permit disengagement of the
_____b_____ from part 15.
sear, thumbpiece

1. (a) fired (b) sear
2. (a) fired (b) thumbpiece
3. (a) cocked (b) sear
4. (a) cocked (b) thumbpiece

● When answering question 5-52, use the following alternatives.

A. The revolver continues to fire as long as you hold the trigger depressed
B. You cock the hammer by hand and pull the trigger for each firing; cocking action rotate the cylinder
C. You pull and release the trigger for each round fired; the hammer cocks automatically and rotates the cylinder when you pull the trigger enough to release the sear from the hammer
D. For each round fired, you pull the trigger, which rotates the cylinder and raises the hammer.
E. After firing a round, you must push forward on the thumbpiece and rotate the cylinder by hand to permit firing of another round

5-52. Which two statements best describe single-action and double-action firing respectively?

1. B; A
2. B; D
3. E; A
4. E; C

5-53. What part of the revolver prevents firing (a) when a loaded revolver is dropped or struck on its hammer, and (b) when the hammer slips from the operator's thumb during cockcing?

1. (a) hammer block (b) rebound slide
2. (a) hammer block (b) thumbpiece
3. (a) rebound slide (b) hammer block
4. (a) rebound slide (b) thumbpiece

5-54. What should be your first step in disassembling the revolver?

1. Cock the hammer
2. Remove the stocks
3. Push forward on the thumbpiece
4. Swing the cylinder out to the right

● When answering questions 5-55 and 5-56, refer to textbook figure 13-11.

5-55. Parts 15, 16, and 17 are removed as one unit after you first remove

1. part 5
2. part 13
3. part 1
4. the sideplate screw directly below the cylinder

5-56. To assemble the late model revolver, what is your first step?

1. Install part 6 to the receiver
2. Install parts 15, 16 and 17 to part 2
3. Install part 2 to the receiver
4. Install part 3 over part 12

Learning Objective: Point out component parts, and disassembly of the .38-caliber Ruger Service-Six revolver.

5-57. How many safety features are incorporated into the revolver?

1. One
2. Two
3. Three
4. Four

5-58. What should be your third step in disassembling the revolver?

1. Remove the grip screw
2. Remove the disassembly pin
3. Cock the hammer
4. Open the cylinder

5-59. What component should you use to depress the trigger guard lock plunger?

1. Hammer strut
2. Cylinder
3. Hammer pivot
4. Disassembly pin

Learning Objective: Identify the parts, controls, disassembly and assembly procedures, principles of operation and functioning of the M14 rifle.

5-60. How is the M14 rifle cooled, operated, and fed?

1. Air-cooled, gas operated, magazine-fed
2. Air-cooled, recoil-operated, magazine-fed
3. Water-cooled, gas-operated, clip-fed
4. Water-cooled, recoil-operated, clip-fed

5-61. How is a loaded magazine installed in the M14 rifle?

1. By inserting the rear end of the magazine into the magazine well until it is engaged by the rear catch, then pushing forward and up on the magazine
2. By inserting the front end of the magazine into the magazine well until it is engaged by the front catch, then pulling to the rear and up on the magazine
3. By inserting the magazine into the magazine well and tapping it lightly on the bottom
4. By inserting the magazine all the way into the magazine well after the bolt has been pulled to the rear, and sliding it straight to the rear

5-62. What is the function of the M14 rifle's gas spindle valve?

1. To control recoil and counterrecoil
2. To regulate the speed of firing
3. To increase or decrease range
4. To control the gases used in firing

5-63. The M14 rifle's adjustable rear sight windage knob is turned clockwise to move the sight to the ___a___ and
right, left
the pinion is rotated clockwise to move the sight aperture ___b___ .
up, down

1. (a) right (b) up
2. (a) right (b) down
3. (a) left (b) up
4. (a) left (b) down

5-64. What action is taken to ensure that the M14 rifle will NOT fire automatically?

1. A modified type of magazine is inserted
2. The selector is replaced with the selector shaft lock
3. The bolt is modified to permit only semiautomatic fire
4. A different firing mechanism is used in place of the regular one

● For questions 5-65 and 5-67, assume you are firing the M14 rifle.

5-65. Your rifle is equipped with a selector shaft lock. After squeezing the trigger to fire one round, you wish to fire the remaining rounds. What must you do?

1. Hold your finger on the trigger
2. Move the operating rod handle all the way to the rear and release for each round
3. Pull the safety back and squeeze the trigger
4. Release the trigger and squeeze it once for each round

5-66. To unload the rifle after firing, what is the first thing you should do?

1. Pull the operating rod handle all the way to the rear
2. Remove the magazine
3. Push the safety rearward into the trigger guard
4. Push the operating rod handle all the way forward

5-67. Besides an empty chamber, which of the following conditions must be present before the rifle is considered clear?

1. Bolt carrier locked to the rear
2. Magazine removed
3. Safety on SAFE position
4. Each of the above

● Questions 5-68 through 5-72 pertain to disassembly, assembly, and nomenclature of the M14 rifle.

5-68. Disassembly to the extent shown in textbook figure 13-21 is recommended for which of the following purposes?

1. For cleaning, lubricating, and maintenance
2. For stowing
3. For transporting
4. All of the above

- When answering question 5-69, refer to textbook figure 13-21.

5-69. In textbook figure 13-21, the respective bolt assembly, firing mechanism, and hand guard assembly are identified by which of the following numbers?

1. 5, 6, 3
2. 5, 6, 4
3. 6, 2, 4
4. 6, 5, 3

5-70. When disassembling the barrel and receiver group, what component of the operating rod and connector group assembly do you remove first?

1. Operating rod
2. Operating rod spring
3. Operating rod guide
4. Connector assembly

5-71. When you are field-stripping the M14 rifle, what is the last part you remove from the barrel and receiver group?

1. Bolt
2. Connector lock
3. Operating rod spring
4. Operating rod spring guide

Assignment 6

Small Arms and Machine Guns (continued)

Textbook NAVEDTRA 10189: Pages 13-28 through 15-73

Learning Objective: Point out descriptive characteristics and principles of operation and functioning of the M870 shotgun.

6-1. What kind of shotgun is the M870?

1. Recoil-operated, magazine-fed semi-automatic
2. Manually operated, magazine-fed, pump action
3. Recoil-operated repeater, slid-action hammer type, magazine-fed
4. Manually operated repeater, slide-action hammerless, magazine-fed

6-2. The safety on the shotgun is provided with
a red band that ____a____ show when
will, will not
the safety is pushed to the ____b____
right, left
to place it in the safe position.

1. (a) will (b) right
2. (a) will (b) left
3. (a) will not (b) left
4. (a) will not (b) right

6-3. To single load the shotgun, you place the
shell into the ______a______ after
slide, ejection port
you press the _____b_____ lock
safety, action bar
inward and move the fore-end ____c____
to the rear,
______.
forward

1. (a) slide, (b) safety (c) to the rear
2. (a) slide, (b) action bar, (c) forward
3. (a) ejection port, (b) action bar, (c) to the rear
4. (a) ejection port, (b) safety, (c) forward

6-4. How do you load the magazine?

1. With the fore-end forward and the gun bottom side up, press shells against carrier and slide them forward
2. With the fore-end to the rear and the gun on its left side, slide shells into the ejection port and forward into the magazine
3. With the magazine removed, slide the shells, base to rear, into the rear of the magazine
4. With the fore-end rearward, remove cap from the front end of the magazine and insert shells base first

6-5. Assume there are no rounds in the magazine but a shell is in the barrel chamber. After pushing the safety on SAFE, you unload the shotgun by

1. rolling the gun sideways, ejection port down, as you pull the fore-end slowly to the rear
2. pushing the action bar lock inward and pulling the fore-end quickly to the rear; shell will eject from the receiver
3. pushing the action bar lock inward, pulling the fore-end slowly rearward, and lifting the shell from the ejection port
4. rolling the gun sideways, ejection port down, as you pull the fore-end quickly to the rear and then slowly pushing it forward

● Question 6-6 pertains to the nomenclature of the shotgun. Refer to textbook figure 13-27 and 13-28.

6-6. The carrier dog, ejector spring, hammer, left shell latch, and slide are identified respectively by which of the following groups of numbers?

1. 8, 17, 1, 28, 54
2. 8, 20, 33, 55, 57
3. 33, 20, 8, 28, 52
4. 33, 17, 1, 28, 52

● Questions 6-7 through 6-9 pertain to maintenance, including disassembly and assembly. Refer to textbook figure 13-27 for parts identification.

6-7. After placing the safety on SAFE, you remove the barrel for cleaning by which of the following actions?

1. By pulling part 27 to the rear and removing part 37
2. By pulling part 27 to the rear and removing parts 4, 35, and 54
3. By removing part 29 and then pulling part 27 to the rear
4. By removing part 29 and sliding part 27 forward off of part 28

6-8. After pushing the safety to SAFE, which of the following actions is necessary to remove the fore-end assembly?

1. Remove part 3
2. Press part 52 inward
3. Remove part 37
4. Each of the above

6-9. Before assembly of part 27, which of the following conditions must exist?

1. The gun must be cocked
2. The action must be closed
3. Part 31 must be released
4. Part 7 must be pushed in

Learning Objective: List characteristics, components and parts, disassembly, assembly, maintenance and operating procedures of the .50 caliber machine gun

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6-10. The .50 caliber machine gun is best described as a

1. recoil-operated, air-cooled, magazine-fed machine gun capable of semiautomatic and automatic fire
2. recoil-operated, air-cooled, belt-fed machine gun capable of semiautomatic and automatic fire
3. gas-operated, air-cooled, belt-fed machine gun capable of automatic fire only
4. gas-operated, water-cooled, belt-fed machine gun capable of semiautomatic and automatic fire

6-11. What is the respective maximum effective range, muzzle velocity (M2 ball), and cyclic rate of fire of the .50-caliber BMG?

1. 1830 m, 3050 fps, 450-550 rpm
2. 1830 m, 2500 fps, 350-400 rpm
3. 7400 yd, 2000 fps, 350-400 rpm
4. 7400 yd, 3050 fps, 450-500 rpm

6-12. What procedure should you follow to remove the first part; the barrel?

1. Rotate the barrel one-half turn clockwise and pull it out
2. Rotate the barrel one-half turn counterclockwise and pull it out
3. Raise the cover, retract and lock the recoiling parts in their rearmost position, disengage the barrel-locking spring, and rotate the barrel to remove
4. Raise the cover, pull recoiling parts to the rear to align the barrel-locking spring with a hole in the side plate, and unscrew and remove the barrel.

6-13. After removing the barrel, you remove
the ____________a____________ after
backplate, retracting handle
moving the bolt to its ________b________
forward, rearmost
position.

1. (a) backplate (b) rearward
2. (a) backplate (b) forward
3. (a) retracting handle (b) forward
4. (a) retracting handle (b) rearward

6-14. In the process of removing the bolt, you accidentally moved the bolt all the way to the rear. What do you do now to align the bolt stud with the clearance hole in the receiver?

1. Slide the bolt all the way forward and then slowly move it to the rear
2. Press in on the oil buffer spring lock and slide the bolt forward
3. Raise the bolt latch and move the bolt forward
4. Push the tips of the accelerator forward to unlock the oil buffer

6-15. The oil buffer group is removed by

1. sliding it out the rear of the receiver
2. removing it together with the bolt as a single unit after the bolt stud is removed
3. pushing forward on the accelerator tips to unlock the buffer assembly from the barrel extension and then removing the two units separately through the rear of the receiver
4. pushing in on the oil buffer body spring lock and then pushing the group out through the rear of the receiver

6-16. General disassembly of the machine gun is completed by

1. removing the oil buffer assembly from the oil buffer body
2. removing the oil buffer group from the barrel extension
3. disassembling the barrel extension
4. disassembling the oil buffer

6-17. How far should the oil buffer tube protrude from the rear of the oil buffer body group when the groups are properly locked in the receiver?

1. 1 in.
2. 1 1/8 in.
3. 3/8 in.
4. 3/4 in.

6-18. What should be the respective positions of the top of the cocking lever and the extractor when you install the bolt into the receiver.

1. Rearward; down
2. Vertical; up
3. Forward; down
4. Forward; up

● Question 6-19 is to be judged true or false.

6-19. The bolt assembly may be installed at the same time you install the buffer group and the barrel extension.

6-20. Before you install the driving spring group, you should make sure that the

1. bolt is all the way forward.
2. bolt is all the way to the rear.
3. oil buffer tube protrudes about one inch from the receiver.
4. tips of the accelerator are rotated forward.

6-21. After screwing the barrel in all the way, you should back it off how many notches?

1. One
2. Two
3. Three
4. Four

6-22. To fire the .50 caliber BMG in semiautomatic mode, you should

1. depress the bolt latch release and engage the bolt latch release lock
2. depress the trigger
3. depress the bolt latch release and depress the trigger
4. slide the bolt to the rear and engage bolt latch release lock

6-23. Assume that a belt of ammunition has been inserted into the machine gun, the first round is engaged by the belt holding pawl and the bolt latch release is locked. What action is necessary to fully load the gun?

1. Pull the retracting slide handle all the way to the rear and release
2. Pull the retracting slide handle all the way to the rear, depress the trigger, pull slide handle to the rear a second time
3. Pull the retracting slide handle to the rear and move it forward, release the bolt, pull retracting slide handle to the rear a second time and move it forward, and again release the bolt.
4. Pull the retracting slide handle all the way to the rear and release twice

6-24. Before you pull the bolt to the rear during unloading, what should you do?

1. Remove the ammunition belt from the gun
2. Raise the top cover
3. Unlock the bolt latch release
4. All of the above

6-25. You have just depressed the trigger and the first round fires. When, during the rearward movement of the recoiling parts, is the bolt unlocked from the barrel extension and by what part or parts?

1. During the first quarter-inch of recoil; by the breechlock depressors
2. During the first inch of recoil; by the breechlock depressors
3. When the barrel extension contacts the accelerator; by the accelerator
4. At the moment the barrel extension is firmly locked to the buffer group; by the accelerator

6-26. What function(s) is/are performed by the accelerator and during what phase of the operation?

1. Accelerating the bolt to the rear; during recoil
2. Moving the bolt to the rear in recoil and locking the barrel extension to the oil buffer body; in counterrecoil
3. Unlocking the bolt from the barrel extension and locking the barrel extension to the oil buffer body during recoil
4. Locking the barrel extension to the oil buffer body during recoil and accelerating the forward movement of the bolt; during counterrecoil

6-27. Headspace is the distance measured between the

1. rear of the firing chamber and the origin of the rifling
2. rear of the barrel and the face of the bolt
3. base of a chambered cartridge and the face of the bolt
4. face of the bolt and the barrel extension

6-28. What should be your first step in checking headspace after adjusting the barrel?

1. Screw the barrel in all the way
2. Cock the gun
3. Remove the barrel
4. Insert a dummy round into the T-slot of the bolt

6-29. What is indicated when you cannot insert the GO end of the headspace gauge, and what corrective action should you take, respectively?

1. Excessive headspace; unscrew the barrel one notch at a time
2. Excessive headspace; screw in the barrel one notch at a time
3. Insufficient headspace; unscrew the barrel one notch at a time
4. Insufficient headspace; screw in the barrel one notch at a time

6-30. What is indicated if the NO-GO end of the gage goes in freely the first time, and what action, if any, should you take?

1. Correct headspace; no corrective action is necessary
2. Excessive headspace; screw the barrel into the barrel extension (one click at a time) until the GO end of the gage enters and the NO-GO end does not
3. Either correct or excessive headspace; screw barrel in one notch at a time until the GO end of the gage can be inserted, and the NO GO end cannot
4. Insufficient headspace; screw in the barrel until the gage is tight

6-31. Why is timing of the .50-caliber BMG so important?

1. Timing ensures that the gun is operating properly
2. If the timing is not set correctly, you cannot chamber a round
3. Timing prevents contact between the front end of the barrel extension and the trunnion block
4. With the gun out of timing, it will not operate as fast as it should

● Question 6-32 is to be judged true or false.

6-32. Timing must be checked and/or set each time headspace is adjusted and whenever timing is questionable.

6-33. What is indicated if the gun will NOT fire with the fire gage installed?

1. Early timing
2. Timing is correct
3. Late timing
4. Improper headspace

6-34. In what manual are detailed procedures for making adjustments on the .50-caliber BMG?

1. FM 23-65
2. OP 3115
3. OP 2665
4. FM 20-21

Learning Objective: List characteristics, principles of operation and functioning, including nomenclature and disassembly and assembly procedures of the 7.62-mm M60 machine gun.

6-35. What are the operational characteristics of the M60 machine gun?

1. Recoil-operated, air-cooled, belt-fed, automatic fire
2. Gas-operated, air-cooled, magazine-fed, semiautomatic and automatic fire
3. Gas-operated, air-cooled, belt-fed, automatic fire
4. Recoil-operated, air-cooled, magazine-fed, semiautomatic and automatic fire

6-36. If, when you are firing at a target 1000 feet away, the projectiles are hitting one-half foot below where they should, how many clicks on the elevation knob will raise the point of impact to the approximate desired area?

1. One
2. Two
3. Three
4. Four

● Question 6-37 is to be judged true or false.

6-37. When the bolt is pulled to the rear, manually, it will automatically return to battery position when released.

6-38. In operation, what part actually moves a round into the feedtray groove?

1. Cam roller
2. Feed cam
3. Upper locking lug
4. Feed pawl

6-39. The bolt of the weapon is completely locked into battery immediately after which of the following actions has occurred?

1. The upper and lower locking lugs have contacted the bolt camming surfaces
2. The extractor has snapped over the rim of the cartridge
3. The bolt has completed a one-quarter clockwise rotation in the barrel socket
4. The operating-rod yoke has fallen into slots in the chambering ramp

6-40. After the machine gun has been fired, how is the bolt unlocked?

1. By force of the empty cartridge case against the face of the bolt
2. By the feed cam as the operating yoke hits the buffer plate
3. By the cover latch as the operating rod moves to the rear
4. By the operating-rod yoke as it moves to the rear

6-41. When you disassemble the M60 machine gun, what should be the respective positions of the bolt, cover, and safety?

1. Forward, open, SAFE
2. Forward, closed, SAFE
3. Rearward, open, FIRE
4. Rearward, closed, FIRE

6-42. When the buffer group is removed from the M60 machine gun, what must you do to remove the buffer yoke?

1. Drive out a retaining pin
2. Pry it out with a screwdriver or similar tool
3. Pull on the buffer to release spring pressure, then lift it out
4. Press in lightly on the buffer and lift it out

6-43. The barrel group can be withdrawn from the receiver after which of the following actions?

1. Raising the barrel lock lever to the vertical position
2. Raising the barrel lock lever to the vertical position and removing the forearm
3. Removing the trigger group and depressing the barrel lock lever
4. Removing the forearm and top cover

6-44. During installation of the trigger housing group, you should position the leaf spring with its bent portion positioned in what direction?

1. Away from the trigger housing
2. Against the trigger housing
3. Upward
4. Downward

Learning Objective: Identify the parts and operating principles of the MK 87 Mod 1 line-throwing adapter kit for the M14 and M16 rifles.

6-45. In the Mk 87 Mod 1 adapter kit, which of the following components is/are NOT included?

1. Projectiles
2. Recoil pad
3. Canister
4. Chemical light wands

6-46. How is the line-throwing launcher secured to the M14 rifle?

1. By internal threads which mate with threads on the rifle barrel
2. By a latch and wire loop which secure to the rifle's bayonet lug
3. By a bayonet joint which fits over the bayonet lug
4. By external threads which mate with threads in the rifle's flash supressor

6-47. What is the maximum number of chemical light wands the line-throwing projectile will accept?

1. One
2. Two
3. Three
4. Four

● Question 6-48 is to be judged true or false.

6-48. The stowage of chemical light wands is restricted to ventilated and topside spaces.

6-49. M14 and M16 grenade cartridges used with the line-throwing projectile are identified in which of the following ways?

1. By their crimped ends
2. By their color-coded bases
3. By their corrugated bodies
4. By their color-coded bodies

6-50. Shot line is buoyant enough to float for a minimum of how many hours?

1. 12
2. 18
3. 24
4. 36

6-51. When the line-throwing projectile is fired from the M14 rifles, what, approximately, is its maximum reliable range?

1. 90 yards
2. 100 yards
3. 110 yards
4. 125 yards

Learning Objective: Describe principles of operation and field-stripping procedures of the M79 grenade launcher.

6-52. The break-open launcher's breech is opened by pushing the barrel locking latch to the ___a___ (left, right) and its safety is placed in the safe position by moving it ___b___ (forward, rearward).

1. (a) left (b) forward
2. (a) left (b) rearward
3. (a) right (b) forward
4. (a) right (b) rearward

● When answering question 6-53 refer to textbook figure 13-77.

6-53. On the M79 grenade launcher, what is the purpose of the hinged trigger guard?

1. To enable a person wearing heavy gloves to fire the launcher
2. To prevent accidental operation of the trigger
3. To simplify opening of the breech
4. To simplify disassembly

6-54. Before the M79 grenade launcher is fired, which of the following checks should you make?

1. Check the bore of the launcher to see that no foreign matter is inside it
2. Check the cartridges to see that they are the proper type and grade
3. Check the launcher for cleanliness and proper functioning
4. Each of the above

6-55. When the M79 grenade launcher is loaded, which of the following actions will ensure that the safety will be on SAFE?

1. Pushing back the housing at the front of the trigger guard
2. Moving the barrel locking latch its full limit of travel to the right and opening the breech end of the barrel
3. Pushing down the handle of the trigger guard assembly
4. Each of the above

6-56. When you fire the M79 grenade launcher from the standing and prone positions, where do you place the butt of the launcher?

1. Shoulder for both positions
2. Right hip for both positions
3. Shoulder for the standing position and ground for the prone position
4. Right hip for the standing position and ground for the prone position

6-57. When the M79 grenade launcher is fired at a target that is within the battle sight range, which of the following procedures should you practice?

1. Fire with the rear sight assembly in the lowered position
2. Fire from a protected position
3. Stop firing if friendly troops move within 265 feet of the target
4. All of the above

● Questions 6-58 and 6-59 pertain to field-stripping the M79 launcher

6-58. You are separating the fore-end assembly from the barrel and receiver group. After removing the appropriate machine screw, what should you do to complete removal?

1. Grasp the receiver firmly with one hand and strike the butt of the stock sharply with the palm of the other
2. Inspect the receiver and chamber to be sure that there is no ammunition in the spaces
3. Pull the front end of the fore-end assembly away and up from the barrel until the lug on the rear sight base is clear of the hole in the upper surface of the fore-end bracket, then pull forward
4. Twist the barrel and receiver group out of the fore-end assembly

● When answering question 6-59, refer to textbook figure 13-84.

6-59. The combination wrench assembly shown in textbook figure 13-84 issued for removing the machine screw that secures or fastens which of the following parts/groups?

1. The barrel group to the receiver group
2. The stock to the receiver group
3. The fore-end assembly to the barrel
4. Both 2 and 3 above

Learning Objective: Identify uses of techniques for holding and throwing, and safety precautions applicable to handling hand grenades.

6-60. For which of the following purposes are hand grenades used?

1. Inflicting casualties
2. Incendiary action
3. Demolition
4. All of the above

6-61. Which of the following characteristics of a hand grenade is affected by the ability of its thrower?

1. Range
2. Effective casualty radius
3. Average delay in detonation
4. Each of the above

6-62. Which of the following is a common characteristic of all hand grenades?

1. Same weight
2. Identical shape
3. Nondetonating on impact
4. Equal effective casualty radius

6-63. In the interest of maximum accuracy and range, a grenade should be thrown like a

1. baseball
2. softball
3. football
4. basketball

6-64. What is the correct procedure for removing the safety pin from a hand grenade?

1. Pull the pin free with a twisting motion
2. Pull the pin free with a sharp jerk
3. Pull the pin free with a steady straight pull
4. Move the pin up and down until it breaks

● Question 6-65 is to be judged true or false.

6-65. The prescribed safety precautions to be observed in handling grenades do not apply to practice grenades.

Learning Objective: Point out safety practices in small arms handling, including issuing of the weapons.

6-66. A pistol or revolver is safe to handle only after it has been completely cleared. When is the .45-cal pistol considered cleared?

1. After you have removed the magazine only
2. After you have removed the magazine and retracted the slide only
3. After you have removed the magazine, retracted the slide, and made sure, visually or by feel, that the chamber is empty
4. After you have removed the magazine; pulled the slide back, released it, and snapped the trigger at least twice

6-67. In the interest of safety, what action should you take when a weapon misfires with a blank cartridge?

1. Check the bore for powder fouling and clear if necessary
2. Completely disassemble and clean thoroughly before further use
3. Fire a standard round with the weapon as soon as possible
4. Return the weapon to an ordnance repair shop for a thorough inspection and check

6-68. What should you do to guard against blowback in a weapon?

1. Replace worn parts
2. Regularly check the bore for obstruction
3. Regularly gauge the weapon for wear
4. All of the above

6-69. Which of the following statements is/are true with respect to the issuance and stowage of small arms?

1. Small arms should always be stowed in secure stowage
2. A weapon should never be issued without the signature of the person receiving the weapon
3. Both 1 and 2 above
4. All oil should be removed from a weapon being issued

Assignment 7

Missile Handling and Magazines; Administration and Security

Textbook, NAVEDTRA 10189: Pages 14-1 through 15-9

Learning Objective: Point out the equipment and procedures for missile-handling from the weapons station to the ship.

7-1. In which of the following publications are ordnance safety precautions, their origin and necessity described?

1. OP 4
2. OP 5
3. OP 1014
4. OP 2665

7-2. How many major NWSs are located in the continental United States?

1. One
2. Two
3. Three
4. Five

7-3. Where is a missile transported to when it will be issued to the fleet in the near future?

1. RFI storage
2. Dock facility
3. Railroad yard
4. Holding area

● Questions 7-4 through 7-6 are to be judged true or false.

7-4. Missiles returned to an NWS are always in a serviceable condition.

7-5. A damaged missile should be turned in to an NWS as soon as possible.

7-6. Naval weapons station act as major stock points for injecting new weapons into the fleet while removing the old and unserviceable items.

7-7. Which of the following containers is designed to handle Standard ER missiles?

1. Mk 183
2. Mk 199
3. Mk 372
4. Mk 632

7-8. The Mk 372 container is available in how many different mods?

1. Six
2. Two
3. Eight
4. Four

7-9. The Mk 372 Mod 4 container is designed to handle which of the following missiles?

1. IT and ITR.
2. Tartar
3. Standard MR
4. Standard ARM

7-10. By which of the following methods is the Mk 372 container lifted?

1. Sling
2. Forklift truck
3. Handlift truck
4. Each of the above

7-11. What type of container is used to handle ASROC missiles?

1. Mk 183
2. Mk 200
3. Mk 372
4. Mk 632

7-12. The Mk 79 Mod 1 missile-handling band is NOT compatible with which of the following missiles?

1. Terrier
2. Tartar
3. Harpoon
4. Standard

7-13. What types of missile-handling dollies are used with Terrier and Standard ER missiles?

1. Mk 6 Mods 1 and 2
2. Mk 6 Mods 1 and 3
3. Mk 6 Mods 2 and 4
4. Mk 6 Mods 3 and 4

● Questions 7-14 through 7-20 are to be judged true or false.

7-14. The wheels on the dolly are locked whenever it is to be moved from one area to another.

7-15. The wheel pockets on the top framework allow loaded dollies to be stacked in storage.

7-16. The Mk 20 cradle can be used to load/unload a Mk 6 transfer dolly if a forklift truck is available.

7-17. The Mk 15 hoisting beam is used to handle Standard missiles only.

7-18. When the Mk 8 dolly loading stand is used to handle Tartar and Standard MR missiles, its top and bottom ring valves are removed.

7-19. The Mk 26 Mod 2 handlift truck adapter makes the handlift truck compatible with various containers.

7-20. Diesel-powered forklift trucks can be operated in atmospheres with explosive mixtures of air and flammable gases safely.

When answering questions 7-21 through 7-25, select from column B the operation that fits the description in column A. Responses may be used once, more than once, or not at all.

A. Descriptions

7-21. The Mk 6 Mod 1 or 3 transfer dolly is used

7-22. When a Standard MR missile is positioned for B-Arm loading

7-23. The lower missile shoes are unlocked and the Mk 2 or 4 dolly is brought into position

7-24. A dolly loading stand is necessary when onloads and off-loads are performed with a transfer dolly

7-25. The Mk 21 guided-missile hoist is fastened to the handling bands

B. Operations

1. Tartar handling rolling the missile
2. Terrier handling
3. Tartar handling container to dolly

Learning Objective: Identify the different replenishment methods available.

7-26. What is the most common method used in the fleet for missile replenishment at sea?

1. STREAM
2. Constant tension highline
3. Modified housefall
4. Fast Automatic Shuttle Transfer (FAST)

When answering questions 7-27 through 7-30, select from column B the replenishment method that fits the description in column A. Responses may be used once, more than once, or not at all.

	A. Descriptions	B. Replenishment Methods
7-27.	The receiving ship may be required to supply personnel to assist the NWS crew	1. Dockside 2. Lighter 3. VERTREP
7-28.	It has many advantages, such as speed and simplicity	
7-29.	When a specially constructed barge designed to carry ammunition is used	
7-30.	Ammunition, cargo, and personnel loads can be transported between ships, ship-to-shore, and shore-to-ship using this method	

Learning Objective: Describe the activities required to maintain missiles aboard ship.

● Questions 7-31 through 7-33 are to be judged true or false.

7-31. A Go/No-Go test must be performed monthly on every round in the magazine.

7-32. The common cause of missile damage can be traced to the inexperienced control panel operator.

7-33. Good housekeeping has to be practiced in all ordnance storage areas.

7-34. Missile inspections can be divided into how many major periods?

1. Five
2. Two
3. Three
4. Four

7-35. During which of the following inspections is cleaning and preservation work performed?

1. Routine
2. Off-load
3. Onload
4. Maintenance

7-36. Which of the following instructions will specify the currently approved materials and explain where and how to apply the compounds?

1. OD
2. OP
3. MRC
4. Both 2 and 3 above

Learning Objective: Identify the different kinds of ammunition magazines including factors in design and location.

7-37. In the arrangement of magazines aboard ship, which of the following factors is/are considered?

1. The ease of supply
2. The best protection
3. The best stowage conditions
4. All of the above

7-38. Which of the following is probably the most significant factor in the design of magazines on board ship?

1. Capacity
2. Type of ammunition-handling equipment
3. Type of ammunition the magazines are to contain
4. Mission of the ship

When answering questions 7-39 through 7-43, select from column B the type of magazine that fits the description in column A. Responses may be used once, more than once, or not at all.

A Descriptions	B Magazines
7-39. Areas equipped with ventilation and sprinkling systems and usually located below decks and often below the waterline	1. Missile 2. Primary 3. Ready-service 4. Lockers
7-40. Used as permanent stowage for part of ship's ammunition allowance near the area it serves	
7-41. Has special restraining latches to prevent any movement of the round in the magazine	
7-42. Closeness is necessary to reduce loading times and support high rates of fire	
7-43. Used for the stowage of special types of ammunition and often located on the weather deck	

7-44. Which of the following alarm circuits is used with a magazine's sprinkler system?

1. F
2. FZ
3. FH
4. FA

7-45. How many water alarm switches does the wet-type sprinkler system used in the Mk 10 GMLS have?

1. Five
2. Two
3. Three
4. Four

7-46. Which of the following alarm circuits is known as the high temperature alarm?

1. FZ
2. FH
3. F
4. FA

7-47. Which of the following alarm circuits provides a security or intruder alert?

1. FA
2. FH
3. F
4. FZ

7-48. What should be your main concern during the daily routine magazine inspections?

1. Cleanliness
2. Temperature
3. Condition of ammunition containers
4. Proper identification and segregation of the contents

7-49. How many different temperature readings can be obtained from a bimetallic minimum/maximum thermometer?

1. Five
2. Two
3. Three
4. Four

7-50. How often should a psychrometer be read?

1. Daily
2. Weekly
3. Monthly
4. Quarterly

7-51. AMMUNITION FAR SIDE signs must be installed on which of the following surfaces?

1. Bulkheads
2. Overheads
3. Decks
4. All of the above

Learning Objective: Identify and describe the use and purpose of publications.

7-52. Which of the following commands issues technical publications which concern GMMs?

1. NAVSEASYSCOM only
2. NAVMATCOM only
3. NAVSUPSYSCOM and NAVMATCOM
4. NAVSUPSYSCOM and NAVSEASYSCOM

7-53. The leading petty officer in your division has advised you to consult NAVORD OP 3000 (Vol. 1), Weapons System Fundamentals. The abbreviation OP in the foregoing designation stands for

1. ordnance publication
2. operations pamphlet
3. operations publication
4. operational priority

7-54. Which of the following organizations may prepare OPs concerning ordnance equipment?

1. NAVSEA
2. Equipment manufacturers
3. Commercial publishers
4. Each of the above

7-55. Which of the following publications deals with the effective use of specific ordnance equipment?

1. Equipment OPs
2. General OPs
3. Ordnance instructions
4. Ordnance notices

7-56. Safety precautions for the GMLS may be found in

1. OP 0, Appendix 3B
2. Volume 4
3. Volume 1
4. Volume 3

7-57. Which of the following ordnance publications are designed to be reference books for a subject matter area?

1. Notices
2. Instructions
3. General OPs
4. System OPs

7-58. Under a new system developed by the Navy, technical publications will have a standardized

1. numbering system
2. contents format
3. construction
4. number of volumes

7-59. Which of the following publications are included under the new numbering system known as TMINS?

1. All OPs
2. All TMs
3. Both 1 and 2 above
4. New or newly revised publications

7-60. What does the letter A in SW394-AC-MMA-010/LS10 INDEX represent?

1. NAVSEA
2. Guided-missile launcher
3. Mk 10 GMLS
4. Mk 13 GMLS

7-61. What type of change does NAVSEASYSCOM use to disseminate urgent information concerning conditions hazardous to the fleet?

1. CH
2. MC
3. ACN
4. FCH

7-62. What type of change provides formal replacement pages that cover configuration changes (ORDALTS and SHIPALTS)?

1. CH
2. MC
3. ACN
4. FCH

7-63. Which of the following characteristics is/are essential for making proper changes to technical publications?

1. Accuracy
2. Timeliness
3. Both 1 and 2 above
4. Applicability

7-64. Which of the following publications takes precedence over all other technical publications where conflicting information is present regarding nuclear weapons?

1. Navy Security Manual
2. Defense Nuclear Agency (DNA) Personnel Training Format
3. Navy special weapons ordnance publications (SWOPs)
4. Nuclear Weapons Management Manual

7-65. Which of the following SWOPs is an index to publications used for multiple service purposes?

1. 0-1
2. 0.1B
3. 30.19
4. 45.21

7-66. Which of the following publications provides up-to-the-minute information on maintenance problems and procedures pertaining to the equipment of a particular weapons system?

1. OP 0
2. OD 9398
3. SMS technical bulletin
4. NAVPUBINST 5215.4B

7-67. Which of the following is NOT an objective of SMS technical bulletins?

1. To provide troubleshooting techniques
2. To provide ORDALT instructions
3. To call attention to technical problems
4. To call attention to new test procedures

Assignment 8

Administration and Security (continued)

Textbook, NAVEDTRA 10189: Pages 15-10 through 15-46

Learning Objective: Point out the purpose and use of shipboard logs and records.

8-1. An accurate, up-to-date ordnance log is an excellent reference for which of the following reasons?

1. To determine methods of repair for certain kinds of casualties
2. To help you get thoroughly acquainted with the equipment
3. To establish an equipments performance history
4. Each of the above

8-2. Which of the following logs is used to record phone numbers, repair tips, and the informal performance of the equipment?

1. Smooth
2. Rough
3. 8810
4. 4855

8-3. Procedures for preparing NAVSEA 4855/2 are contained in what NAVSEA notice?

1. 4855
2. 4855/1
3. 4855/2
4. 4855/5

8-4. Who normally maintains the weapons system smooth log?

1. The leading chief
2. The executive officer
3. The weapons officer
4. The operations officer

8-5. Which of the following entries is NOT recorded in the small arms log?

1. Weapons type
2. Serial number
3. Weapons location
4. Ammunition type

When answering questions 8-6 through 8-8, select from column B the log/record that fits the description in column A. Responses may be used once, more than once, or not at all.

	A. Descriptions	B. Logs/Records
8-6.	It is the permanent chronological record of all magazine temperatures	1. Magazine temperature log
		2. High temperature notebook
8-7.	It is used to record the daily temperatures of a magazine	3. Magazine temperature card
8-8.	It is filled out after all shipboard magazine temperatures are taken	4. Daily magazine temperature report

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● Questions 8-9 through 8-14 are to be judged true or false.

8-9. The GMSR remains at an NWS while the missile is transferred around the fleet.

8-10. The CSF is used to list all the major components installed within a particular missile configuration.

8-11. The PUDS is used to record all the data concerning the steering unit.

8-12. The results of all NWS propulsion unit inspections, tests, and repairs are documented on the PUHS.

8-13. The CDL lists all the major items within a unit by their assigned part number.

8-14. The information on a test traveler card sets the desired test program and permits testing to be performed.

Learning Objective: Recognize weapons system administration forms/reports and identify their basic content.

8-15. The basic reference document in the PMS is the maintenance index page (MIP). Its contents include which of the following information?

1. Safety precautions for the various maintenance jobs
2. Required tools and material for a given maintenance requirements
3. A brief description of each maintenance requirement
4. All of the above

8-16. Where should you look for a listing of the tools, parts, and materials needed in performing a scheduled preventive maintenance task on a GMLS?

1. Weekly schedule
2. Maintenance index page
3. NAVSEA technical manual
4. Maintenance requirement card for the GMLS

8-17. Assume that three identical electrical motors are covered by one maintenance requirements card (MRC). What document is prepared to identify the locations of the motors?

1. Maintenance index page
2. Feedback report
3. Equipment guide list
4. Cycle schedule

8-18. Individual assignment of personnel to maintenance jobs by the work center supervisor is provided on the

1. cycle schedule
2. weekly schedule
3. quarterly schedule
4. maintenance requirement card

8-19. What form is used for reporting deferred and completed maintenance actions?

1. OPNAV 4790/2K
2. OPNAV 4790/2Q
3. OPNAV 4790/2L
4. OPNAV 4790/2P

8-20. What form is provided for supplemental information, such as drawings?

1. OPNAV 4790/2K
2. OPNAV 4790/2L
3. OPNAV 4790/2R
4. OPNAV 4790/2P

8-21. Which of the following forms are used for obtaining necessary spare parts?

1. OPNAV 4790/2P and OPNAV 4790/2Q
2. OPNAV 4790/2L and OPNAV 4790/2K
3. OPNAV 4790/2R and OPNAV 4790/2L
4. NAVSUP 1250 and DD 1348

8-22. Which of the following is the basic management tool for accomplishing repairs aboard ship?

1. COSAL
2. CSMP
3. MDS
4. PMS

8-23. The commanding officer's narrative report (CONAR), which is the CO's overall appraisal of the weapon system, includes which of the following comments?

1. The quality of the training of personnel
2. Technical assistance requested and received
3. Recommendations for improvement
4. All of the above

8-24. Which of the following documents are issued to complete the DCAP information loop?

1. Periodical status reports
2. ORDALT instructions
3. Updated allowance parts lists
4. Procedural changes

Learning Objective: Point out the purpose and fundamentals of alterations, SECAS, and SAIL.

8-25. Which of the following alterations must be approved by the CNO?

1. ORDALTS
2. SHIPALTS
3. NAVALTS
4. AIRALTS

8-26. Approved alterations to ordnance equipments under the cognizance of NAVSEASYSCOM are called

1. NAVALTS
2. ORDALTS
3. SHIPALTS
4. Equipment alts

8-27. What organization is responsible for the completion and verification of SMS equipment ORDALTs?

1. NAVSEA
2. NSWSES
3. DON
4. DOD

8-28. In which of the following places should you document the completion of an ORDALT?

1. In the ORDALT file
2. On the ORDALT plate
3. On a 4790/CK
4. Both 2 and 3 above

8-29. From which of the following sources does the weapons system file receive initial or updated configuration information?

1. The SAIL
2. 4790/CK
3. Shipboard validations
4. Each of the above

8-30. All commands concerned with armament configuration are furnished a listing of installed shipboard ordnance equipment by what reporting system?

1. MDS
2. ORDLIS
3. SECAS
4. SAIL

Learning Objective: Identify and describe aspects of the supply system pertinent to GMMs.

8-31. Which department is responsible for supporting the material needs of the command?

1. Weapons
2. Supply
3. Operations
4. Engineering

8-32. Which of the following items are considered as consumable?

1. Typewriters
2. Binoculars
3. Cleaning solvents
4. Stopwatches

8-33. Besides identifying component parts, an IPB is especially useful as an aid in

1. determining the number and locations of lubrication points during preventive maintenance
2. making adjustments requiring very close tolerances
3. pinpointing the location of malfunctioning parts during troubleshooting
4. determining the relative location of parts during reassembly of a unit or mechanism

8-34. You are instructed to find the identification of an item of equipment aboard ship. The nameplate is missing and you are not sure of the item's nomenclature. In which of the following parts of the COSAL should you look first?

1. Part I
2. Part II
3. Part III
4. Part IV

8-35. Which part of the COSAL should you consult to determine the authorized storeroom allowance of repair parts to support an item of equipment aboard ship?

1. Part I
2. Part II
3. Part III
4. Part IV

- Questions 8-36 through 8-38 are to be judged true or false.

8-36. If a repair part is NIS the requisition is cancelled.

8-37. A work center's supply log provides a means of keeping track of and accounting for all ordered supply parts.

8-38. All supply documents require a requisition number.

8-39. Which of the following ways should repairables be packaged for return to the supply department?

1. In an appropriately designed container
2. In a plastic bag stuffed with wadded paper
3. With all usable parts removed
4. With the defective component removed

8-40. Which of the following publications contains all the current COG OI publications and COGII forms stocked at NPFC?

1. NAVSUP P-486
2. NAVSUP P-2001
3. NAVSUP P-2002
4. NAVSHIP P-2665

8-41. How many basic types of microfiche software are available?

1. Five
2. Two
3. Three
4. Four

8-42. What publication is arranged in NSN sequence and lists such information as units of issue, unit price, and shelf life?

1. APL
2. COSAL
3. FSC
4. NMDL

Learning Objective: Describe the necessity for, and the implementation of security in the Navy.

8-43. Who is/are directly responsible for safeguarding classified material on board a ship?

1. Security officer
2. Weapons officer
3. Personnel who handle the material
4. Commanding officer

8-44. Which of the following classification designations is the most significant to national security?

1. Secret
2. Top secret
3. Confidential
4. Unclassified

8-45. Who must indoctrinate new members as to the specific security requirements related to their job?

1. Division officer
2. Security officer
3. Work center supervisor
4. Commanding officer

8-46. The designated area where one or more nuclear weapons is located is known as the

1. controlled position
2. exclusion area
3. limited area
4. buffer zone

8-47. When performing any operation in which access to nuclear weapons may be afforded, at least two people, each with knowledge to detect unauthorized procedures in regard to security and the task being performed, must be present. This criterion is called the

1. ship's policy
2. two-man rule
3. controlled-position rule
4. limited-area rule

8-48. Which of the following groups consists of two or more security force members capable of immediate response to any security irregularity?

1. Security alert team
2. Backup alert force
3. Reserve force
4. Augmentation force

8-49. Which of the following systems is/are used to control exclusion area entry?

1. Formal entry list
2. Controlled badge
3. Visitor escort system
4. All of the above

8-50. What officer appoints designated key and lock custodian?

1. Weapons officer
2. ASW officer
3. Commanding officer
4. CNO

8-51. How much time is allowed for the SAT to get armed and be on station?

1. 5 minutes
2. 10 minutes
3. 15 minutes
4. 4 hours

- Questions 8-52 through 8-57 are to be judged true or false.

8-52. Once a guard is armed, his weapon should be loaded.

8-53. Orders and instructions for each security post/station must be posted and emphasized.

8-54. Security "exercises" are conducted to ensure the security force is proficient in its duties.

8-55. Personnel not certified as meeting the standards of the PRP may perform duties in controlled or critical positions if properly supervised.

8-56. All personnel assigned to PRP positions must have appropriate security clearances.

8-57. A proficiency certification indicates that the individual is professionally or technically skilled in the duties to be performed.

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PRINT OR TYPE

NRCC Gunner's Mate M 3&2
Volume 2, NAVEDTRA 10189

NAME ____________________ ADDRESS ____________________
Last First Middle Street/Ship/Unit/Division, etc.

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City or FPO State Zip

RANK/RATE ________ SOC. SEC. NO. ____________________ DESIGNATOR ________ ASSIGNMENT NO. ________

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PRINT OR TYPE

NRCC Gunner's Mate M 3&2
Volume 2, NAVEDTRA 10189

NAME ______________________ ADDRESS ______________________
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Volume 2, NAVEDTRA 10189

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PRINT OR TYPE

NRCC Gunner's Mate M 3&2
Volume 2, NAVEDTRA 10189

NAME ______________________ ADDRESS ______________________
Last First Middle Street/Ship/Unit/Division, etc.

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City or FPO State Zip

RANK/RATE ________ SOC. SEC. NO. ______________ DESIGNATOR ______ ASSIGNMENT NO. ______

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PRINT OR TYPE

NRCC Gunner's Mate M 3 & 2
Volume 2, NAVEDTRA 10189

NAME ____________________ ADDRESS ____________________
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